A STUDY OF SOME FACTORS AFFECTING TUBER NUMBER IN *Solanum tuberosum* L.

by

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SUMMARY

A series of field experiments were carried out to investigate the effects of differences in the previous history of the mother crop, sprout number, sprout development and in the environment in the early stages of post-emergence growth on stem and tuber production.

1. There was no effect of sprouting in the winter preceding the production of the mother crop, or burning off the mother crop on sprout, stem or tuber production in the current season in either Arran Pilot or Majestic.

2. Delay in setting up previously cold-stored tubers to sprout resulted in an increase in sprout and mainstem number in both varieties. Early-sprouted tubers showed a greater degree of lateral-branch development of the sprout and mainstem than late-sprouted tubers. The response in tuber number and yield varied from year to year but, on average, late-sprouting produced more tubers than unsprouted seed: 10% more in Arran Pilot and about 3% more in Majestic. Late-sprouted seed usually produced more tubers than early-sprouted seed. Where crops matured naturally, yields at harvest in both sprouted and unsprouted seed were similar. In 1965 tuber bulking rates in unsprouted seed were not constant and appeared to show changes in rate associated with the pattern of foliage growth and the prevailing weather conditions.

3. Efforts to induce differences in the number and type of lateral branches on the sprout and thus stem and tuber production in Arran Pilot, by clipping off the apex of the sprout at different stages of development, were not successful. An increase in an index of sprout development (the number of lateral branches + sprouts per tuber) led to an increase in stem numbers at ground level and tuber number but the relationship was not a close one. It was difficult to induce lateral-branch development of the sprout in Majestic. Although an increase in the number of lateral stems led to an increase in tuber number this was not as large as an increase per stem as from a unit increase in mainstem number.

4. It was clear from the results of a planting date experiment and a shading experiment that differences in tuber number occurred irrespective of changes in mainstem number. It was suggested that these differences were brought about by differences in the environment, particularly soil water content, light intensity and air temperature, at the time of tuber initiation.

5. It was argued that differences in the response in tuber number to sprouting from year to year could be related to differences between the treatments in 1) lateral-branch development of the sprout at planting, and 2) the environment at tuber formation.

Chapter I

INTRODUCTION

In the potato crop the control of tuber number and size involves the regulation of the number of mainstems per hill and the distribution of hills along the row (Bates, 1935).

A number of seed size and spacing experiments (Bates, 1935; Roer, 1955; Frederiksen, 1957; Taha, 1961; Bremner and El Saeed, 1963; Bremner and Taha, 1966) indicate that an increase in seed size results in an increase in the number of mainstems per hill and a decrease in the number of tubers per mainstem. However, the increase in the number of mainstems per hill more than offsets this inverse relationship, resulting in an increase in the number of tubers per hill. The effect of spacing on mainstem numbers per hill is relatively small (Taha, 1961; Bremner and Taha, 1966), though, with an increase in the spacing between hills, there is an increase in the number of tubers per hill. However, this is insufficient to offset the reduction in tuber number per acre arising from the reduction in mainstem densities per acre with an increase in spacing distance. In contrast, the response in total yield to changes in mainstem density is relatively small over the range of mainstem densities commercially employed (Haughdal, 1957; Taha, 1961; Bremner and Taha, 1966; Toosey, 1963; Bleasdale, 1965). In general, as a result of these reactions on tuber number and total yield there is a decrease in the average size of the tuber (Taha, 1961; Toosey, 1963; Bremner and Taha, 1966) and an increase in seed yield with an increase in mainstem number per hill (Goodwin, 1964; J.C. Holmes, unpublished data - table 1).

With sprouted seed, the number of mainstems per hill in the field is directly related to the number of large growing sprouts per tuber at planting time (Morris, 1966 - quoted by Moorby, 1967). The number and size of the sprouts growing at planting time is controlled largely by temperature (Davidson, 1958; Headford and Ingersent, 1962) though high light intensities and dry conditions during storage have been shown to increase the number of sprouts per tuber (Headford and Ingersent, 1962).

When the tuber is lifted, the buds are normally in a resting state (Emilsson, 1949) during which time little or no growth takes place. Under conditions favourable for growth, i.e., above 5°C, the apical bud is the first to grow and progressively inhibits the growth of the lateral buds. Inhibition is more rapid with an increase in temperature (Goodwin, 1964) and apical dominance is quickly achieved when sprouting takes place at high temperatures (10° - 15°C). Tubers which have been stored below 5°C after harvest (to prevent bud growth) show, on transfer to more favourable conditions for bud growth, a marked decline in apical dominance, resulting in a more even growth of a larger number of sprouts (Goodwin, 1964). The number of sprouts that continue to grow

Table 1 - Effect of variety and date of sprouting on sprout, stem and tuber production in 1961, 62, 63 and 64.

	Sprout number per tuber at planting	Mainstem number per hill	Total stem number at ground level per hill	Total tuber number (10^3 per acre)	Total yield (tons per acre)	Seed yield (tons per acre) $1\frac{1}{4}''-2\frac{1}{4}''$
ARRAN PILOT						
1961						
Sprouted in November	10.8	3.1	14.4	250	16.0	11.8
Sprouted in February	14.9	2.8	11.9	222	14.9	10.9
Unsprouted	-	7.2	10.6	245	15.9	12.3
S.E.				± 5.8	± 0.4	± 0.3
1962						
Sprouted in February	8.2	2.4		135	14.6	7.5
Sprouted in March	11.2	2.6		131	14.3	7.0
Unsprouted	-	3.6		126	15.0	7.3
S.E.				± 3.3	± 0.4	
1963						
Sprouted in February	7.5	3.6		221	9.4	6.1
Sprouted in March	8.5	3.2		246	10.0	6.1
Unsprouted	-	5.2		240	8.1	5.5
S.E.				± 9.5	± 0.5	± 0.37
1964						
Sprouted in November	5.2	1.3		153	16.2	8.3
Sprouted in March	8.5	2.8		184	17.6	9.6
Unsprouted	-	2.9		156	16.0	8.5
S.E.				± 5.0	± 0.5	± 0.47

Table 1 (contd.)

	Sprout number per tuber at planting	Mainstem number per hill	Total stem number at ground level per hill	Total tuber number (10^3 per acre)	Total yield (tons per acre)	Seed yield (tons per acre) 1¼"-2¼"
MAJESTIC						
1961						
Sprouted in November	4.5	1.4	4.6	192	22.5	11.4
Sprouted in February	13.7	2.0	6.0	200	21.9	12.2
Unsprouted	-	4.3	4.8	230	21.1	15.1
S.E.				± 5.8	± 0.4	± 0.3
1962						
Sprouted in February	8.3	2.7		112	16.6	6.7
Sprouted in March	8.4	2.8		117	17.4	5.2
Unsprouted	-	3.6		126	16.7	5.0
S.E.				± 3.3	± 0.4	
1963						
Sprouted in February	7.9	2.4		136	10.2	5.9
Sprouted in March	8.6	3.2		126	10.2	5.7
Unsprouted	-	3.7		154	10.0	6.5
S.E.				± 9.5	± 0.5	± 0.37
1964						
Sprouted in November	5.8	1.7		163	19.0	7.1
Sprouted in March	8.8	2.4		175	19.8	7.3
Unsprouted	-	2.5		145	18.5	7.3
S.E.				± 5.0	± 0.5	± 0.47

increases with an increase in the length of storage at low temperature (Kawakami, 1953). Sprouting techniques for the control of sprout length, sprout number and mainstem numbers have been reviewed by Toosey (1963, 1964) and Goodwin (1964).

Control of mainstem numbers within the hill by sprouting has been practised in both early (Thomas and Eyre, 1951) and maincrop varieties for ware production (Toosey, 1958, 1962, 1963; Terrington Experimental Husbandry Farm, 1960, 1961, 1962). An increase in the number of sprouts per tuber resulted in an increase in the number of mainstems and tubers per hill and a decrease in the average size of the tubers (Toosey, 1962). The response varied with variety (Toosey, 1963) for there were differences in the relationship between the number of tubers per mainstem and the number of mainstems per hill with an increase in mainstem density per hill, Majestic showing a greater reduction in the number of tubers per mainstem than Bintje with an increase in the number of mainstems per hill. Bremner and El Saeed (1963) considered that the inverse relationship between tuber numbers per stem and mainstem numbers might frustrate attempts to increase tuber number and thus seed yield by manipulation of stem and sprout numbers.

Sprouting for seed production has not been extensively explored, but Eckersall and Bremner (1964) found little advantage in seed yield with multi-sprout over single-sprout tubers in either Majestic or King Edward. Between 1961 and 1964 a series of experiments (J.C. Holmes, unpublished results - table 1) at Edinburgh, using the varieties Arran Pilot and Majestic, were undertaken to explore the possibilities of sprouting to control mainstem number, tuber number and tuber size for seed production compared with the use of unsprouted tubers.

In general, delay in setting up for sprouting of previously cold-stored tubers resulted in a greater number of sprouts and mainstems; unsprouted tubers producing the greatest number of mainstems. On average there was little response to sprouting in tuber number or seed yield in either variety but a feature of the results was the year to year variation in the slope of the response in tuber number to increases in mainstem number per hill. In Majestic there was a good relationship between main-stem and tuber number (r = 0.75 **, d.f. 9 - calculated from an analysis within years and among treatments) but not in Arran Pilot (r = 0.20 N.S., d.f. 9). In Arran Pilot in 1962, 1963 and 1964 and in Majestic in 1964 the unsprouted treatments produced fewer tubers at harvest than the March sprouted treatments even though the unsprouted tubers produced more mainstems.

Das Gupta (1962) has shown that a single well-developed sprout giving rise to a single mainstem and a large number of above ground lateral stems, which arise from the below ground parts of the mainstem, can compensate in tuber number for many poorly developed mainstems in the variety Arran Pilot. Since the degree of sprout development at planting time and the number of total stems at ground level in the Edinburgh experiments were not recorded in all years,it is difficult to separate the effects of mainstem number and the degree of lateral branch development on tuber number. In addition Madec and Perennec (1955) have shown that tubers obtained from late-maturing crops show a greater degree of apical dominance than tubers from early-maturing crops when set up to sprout at the same time. Differences in crop maturity of about 10-14 days occur between crops grown from sprouted and unsprouted seed. Thus the response to sprouting may differ when seed from these crops are set up to sprout at the same time in the winter prior to planting.

It has been maintained that a number of other factors can affect tuber number, for example, 1) soil moisture (Pratt, 1952; Peeler, 1966; Llewellyn, 1962, 1967), 2) nutrient supply (Dickins, 1960; Burrage, 1965; Hanley et al., 1965; Simpson and Crooks, 1965; Armitage, 1965, 1967), 3) the time of tuber initiation (Goodwin, 1964), and 4) possibly the state of haulm development at tuber initiation (Bodlaender and Algra, 1967; Humphries and Dyson, 1967).

Since in the Edinburgh experiments (1961-64) unsprouted seed emerged 10-14 days later than sprouted seed, the effects of stem number and development on tuber number may be confounded with the effects of the environment during the early stages of growth.

Thus a series of experiments were carried out from 1965-68 to investigate the effects of:

1) the previous history of the mother crop,
2) the degree of sprout development at planting time, and
3) the environment during the early stages of foliage and tuber growth on stem numbers, tuber numbers and yield.

Chapter II

EXPERIMENTAL

SECTION I

The effect of the previous history of the mother crop

Experiment 1 - 1964-65
Experiment 2 - 1965-66

1. Introduction

Sadler (1961) demonstrated that the cessation of bud growth on the daughter tubers during their growth in the field is a progressive phenomenon starting with the basal bud and ending with the cessation of growth of the apical bud on the death of the foliage.

The apical bud is usually the first to start growing on the resumption of favourable conditions (above $5^{O}C$) immediately after harvest. Although the lateral buds also begin to grow they are soon inhibited, and the apical bud or buds become dominant (Goodwin, 1964). The tuber in this state is apically dominant. The maintenance of unfavourable conditions for bud growth for some time after harvest results, on transfer of the tuber to more favourable growing conditions, in a more even growth of a larger number of buds (Goodwin, 1964).

The earlier tubers are harvested from a uniformly treated crop the longer is the delay before bud growth restarts (Koltermann, 1927; Rosa, 1928; Emilsson, 1949; Wright and Peacock, 1934) although Burton (1963) has shown that this trend may be obscured where the difference between the harvest dates is small.

In practice the haulms of most seed crops are burnt off before natural maturity occurs. However, in experiments where crops have been defoliated at different times, but left in the ground under identical conditions, and harvested at the same time, there was little difference in the time at which sprout growth commenced (Emilsson, 1949; Burton, 1963). Similarly Goodwin (1964) found little effect of the centre of seed production, haulm destruction or post-harvest treatment of the seed on sprout or stem growth, tuber number, bulking rate or yield in the following season. These comparisons, however, were complicated by the fact that 1) on some of the treatments tubers were desprouted before they were set up to sprout, and 2) the environmental conditions during sprouting varied considerably from centre to centre.

However, Madec and Perennec (1955) have noted that tubers obtained from late plantings in the previous season showed a delay of 15 days before bud growth started when set up to sprout at the same time as tubers obtained from early plantings. Tubers from the late plantings showed a greater degree of apical dominance at planting time but the effects on stem numbers were not described. Differences in maturity of up to two weeks are found between sprouted and unsprouted crops and it would be expected that tubers from unsprouted crops would produce fewer sprouts, stems and tubers than tubers from sprouted crops when set up to sprout at the same time. Therefore, from a practical point of view the seed producer adopting a sprouting regime and starting with his own seed obtained from sprouted crops would expect less advantage from sprouting compared with unsprouted seed obtained from an unsprouted crop.

The purpose of the experiments described here was to test whether differences in the previous history of the mother crop affected the response to sprouting. Two experiments, similar in design, were carried out: one in the 1964-65 season and the other, which incorporated two extra treatments, haulm destruction vs. natural maturity, in 1965-66.

Experiment 1 - 1964-65

2. <u>Materials and methods</u>

F.S. - Scottish grade seed of both Arran Pilot and Majestic was obtained from an experiment treated in the following way.

1963-64

I - Sprouted at 50° - 55°F in November 1963 till the sprouts were 1 cm. long and then transferred to 35° - 45°F till planted.

A - Sprouted at 40° - 50°F throughout the storage period.

M - Sprouted at 50° - 55°F in March 1964 till the sprouts were 1 cm. long and then transferred to 35° - 45°F till planted.

O - Unsprouted; cold stored at 35° - 45°F till planted.

Seed tubers from each replicate of this mother crop were sorted into two seed sizes (mean tuber size 98 g and 49 g) and given the following treatments in the current season (1964-65):

1964-65

N^1 - Sprouted in November (1964) at 50^o - 55^oF till sprouts 1 cm. long and then transferred to 35^o - 45^oF till planted.

M^1 - Sprouted in March (1965) at 50^o - 55^oF till sprouts 1 cm. long and then transferred to 35^o - 45^oF till planted.

O^1 - Unsprouted; cool stored at 35^o - 45^oF and white sprouts removed at planting time (only necessary in Arran Pilot).

Table 2 - Approximate dates of senescence of the mother crop in 1964.

	Arran Pilot	Majestic
I	7/9/64	7/10/64
A	3/9/64	7/10/64
M	9/9/64	7/10/64
O	18/9/64	15/10/64

All trays were equalised for the weight and the number of tubers. Five tubers of approximately 98 g and 49 g from each treatment were marked and sprout growth recorded at 2-weekly intervals until planting time. Tubers were cool stored (35^{o} - 45^{o}F) to prevent premature sprout growth until required for chitting. An 8 hr.-day illumination was used during sprout growth and the trays were moved around weekly to even out differences in the lighting pattern in the store room. Storage temperatures are shown in figure 1 of the Appendix. In Arran Pilot M^1 and O^1 treatments, sprouts had appeared in February and these were removed in M^1 before setting up for sprouting and in O^1 on 13th April. At planting time, unsprouted tubers were scored for the incidence of skin spot and the results are presented in table 1 of the Appendix. Sample tuber weights and the dates of movement of trays are given in the Appendix, tables 2 and 3 respectively.

The field experiment was of split-plot design with variety and size in main plots and the twelve treatments (all combinations of I, A, M, O, and N^1, M^1, O^1) on sub-plots. There were two replicates. The experiment was carried out on the University Farms, following a barley crop on a gravelly sandy loam at 660'. Ten tons of F.Y.M. were applied in the autumn and ploughed in and 100 units of N and P_2O_5 and 120 units of K_2O were broadcast in April before working. Planting took place on 25th April. The drills were ridged up once and no cultivation took place after the tubers were covered. Weeds were controlled by spraying with a mixture of linuron (3 lb./acre A.I.) and paraquat (3 lb./acre) in 30 gallons of water on 14th May. Protective blight spraying was carried out on 18th, 27th

July and 20th August. Provision was made in the layout of the experiment, by the inclusion of two extra guard rows every 10 drills (two plot widths), to allow tractor spraying without wheel damage to the plots. The crop was allowed to mature naturally. Harvest took place on 19th November and the tubers were graded into four sizes and the number and the weight of tubers in each grade was recorded. The individual plots were 54' x 5 drills, the outside drills being guard rows. Half of this area was used for a final harvest of 27 plants ($\frac{1}{460}$ acre) and the other half for sampling during the growing season beginning about 2 weeks after the 50% emergence stage and continuing at approximately 2-weekly intervals until the end of August.

The sampling occasions were: (1) 16/17 June, (2) 5/6 July, (3) 19/20 July, (4) 9/10 August, and (5) 19/20 August.

Samples at each lift consisted of 3 adjacent plants, one plant lifted from each of the ridges in the plot. A row of 3 guard plants was left between successive samples of 3 plants. The foliage was cut off at ground level and bagged. Stems and tubers were then dug and washed. Dry weights were obtained, in the early stages of growth, by oven drying the entire sample at 100°C. Later on, sub-samples of about $\frac{1}{5}$ of the weight of the total sample were dried and total dry weight computed from the percentage dry weight and the total sample fresh weight. Tubers were divided into the following grades by weight: 0-25 g, 25-50 g, 50-75 g, 75-100 g, 100-125 g, 125-150 g, 150-175 g, 175-200 g, 200-225 g, 225-250 g, 250-275 g, 275-300 g, > 300 g, and number and weight recorded in each grade. The number of mainstems, and the number of stems at ground level were recorded. Coefficients of variation were fairly high, of the order of 20% of the sample mean for a series of attributes. An estimate was made of the occurrence of the disorder 'coiled-sprout' (Pitt et al., 1964; Ali, 1968). In this experiment symptoms varied from a slight distortion of the stem with little fasciation to completely looped stems showing marked fasciation. In many cases of severe looping accompanied by fasciation, the terminal bud died, resulting in the development of lateral branches from the underground portion of the mainstem. Records were taken of the number of coiled mainstems which had emerged by the terminal shoot and those that had not, together with the lateral branches arising from the portions of the mainstem below ground level.

In addition field scores were carried out on the following dates: 24th May, 4th, 10th, 14th June, to estimate the date of 50% emergence and 10th, 20th, 30th August and 11th, 22nd September to estimate the date of 95% senescence (Hanley et al., 1965).

3. Results

3.1. Sprout growth during the storage period, sprout development at planting time and stem growth

3.1.1. Start of sprout growth (table 3)

In both Arran Pilot and Majestic sprouted in November of the current season (N^1) there was a tendency for early crop maturity to give earlier sprout growth. Although I and A were subject to different storage environments there was little difference between them in maturity. There was no difference in the start of sprout growth due to any of the previous season's treatments (I, A, M, O) when sprouting took place in March of the current season (M^1).

3.1.2. Sprout number (table 4)

There was no effect of the previous season's treatments (I, A, M, O) on sprout number during growth in the storage phase at either date of sprouting (N^1, M^1) in the current season (figures 1 and 2).

March-sprouting in the current season (M^1) resulted, in both varieties, in a greater number of sprouts per tuber at planting time than November-sprouting (N^1). Arran Pilot produced a greater number of sprouts than Majestic at both dates of sprouting. In Arran Pilot fewer sprouts started to grow with November-sprouting (N^1) than with March-sprouting (M^1) but in Majestic similar numbers of sprouts started to grow

Table 3 - Effect of the previous and current season's treatments on the start of sprout growth when tubers were set up to sprout in November and March.

		ARRAN PILOT		MAJESTIC	
		Sprouting in the current season		Sprouting in the current season	
		November (N^1)	March (M^1)	November (N^1)	March (M^1)
Sprouting in the previous season	I	26 Nov.	7 Feb	14 Dec.	9 Mar.
	A	25 Nov.	7 Feb.	15 Dec.	9 Mar.
	M	27 Nov.	7 Feb.	20 Dec.	9 Mar.
	O	2 Dec.	7 Feb.	25 Dec.	9 Mar.

Figure 1 Effect of the previous season's treatments on the change in sprout number with time when the tubers were set up to sprout in November of the current season.

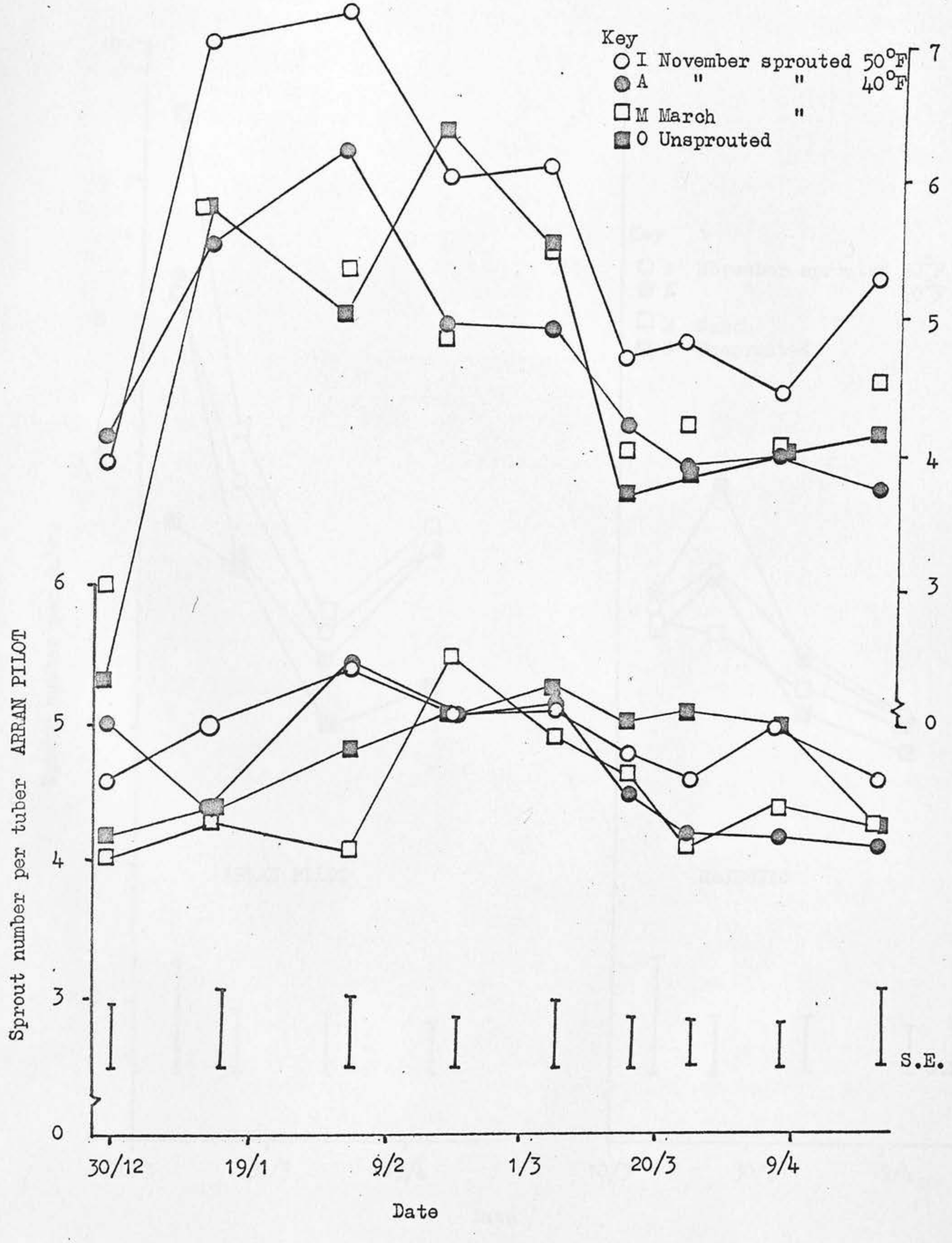


Figure 2 Effect of the previous season's treatments on the change in sprout number with time when the tubers were set up to sprout in March of the current season.

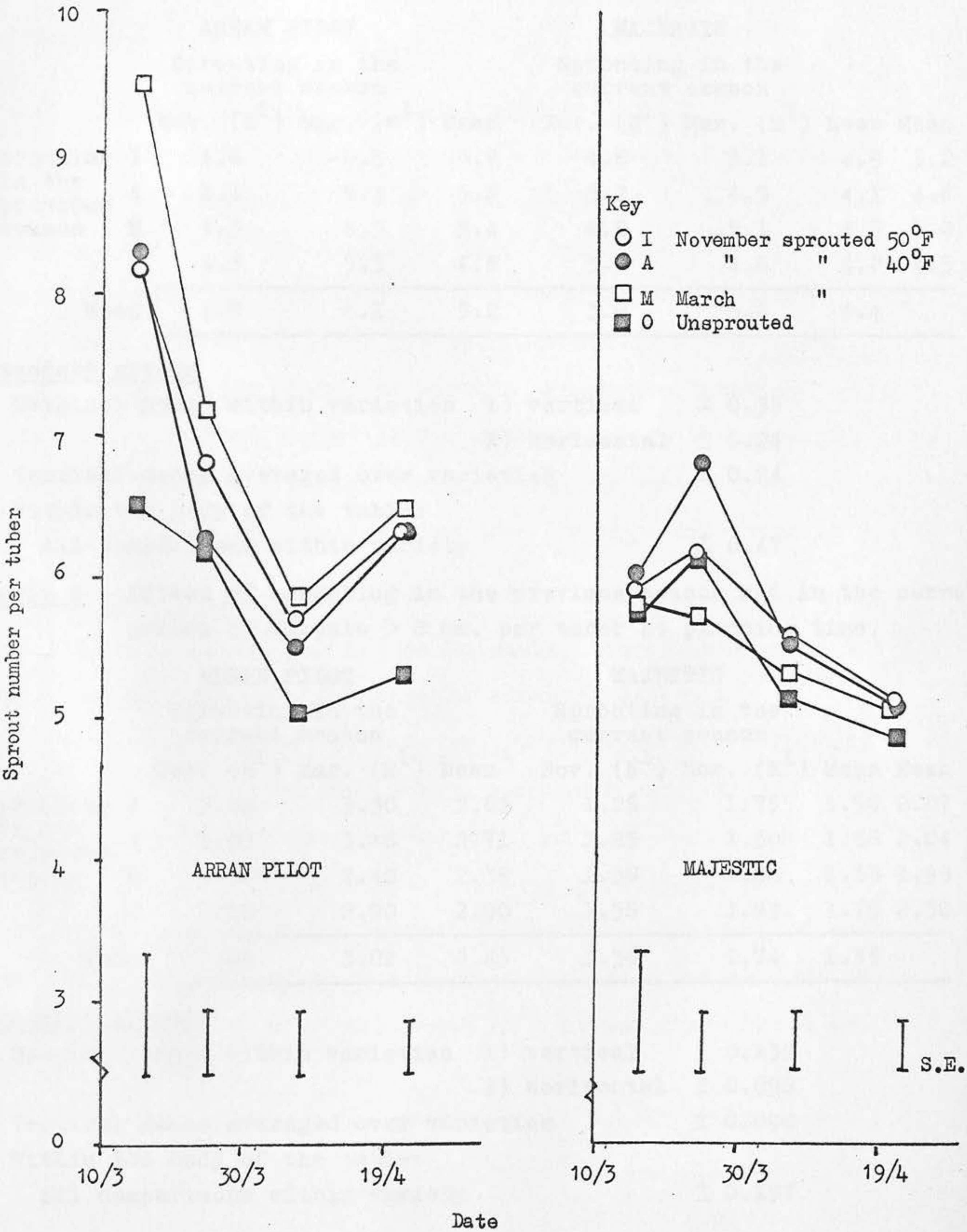


Table 4 - Effect of sprouting in the previous season and in the current season on sprout number per tuber at planting time.

		ARRAN PILOT			MAJESTIC			
		Sprouting in the current season			Sprouting in the current season			
		Nov. (N^1)	Mar. (M^1)	Mean	Nov. (N^1)	Mar. (M^1)	Mean	Mean
Sprouting in the previous season	I	4.6	6.3	5.4	4.8	5.1	4.9	5.2
	A	4.1	6.3	5.2	3.2	4.9	4.1	4.6
	M	4.3	6.5	5.4	4.0	5.1	4.5	5.0
	O	4.3	5.3	4.8	3.6	4.8	4.2	4.5
Mean		4.3	6.1	5.2	3.9	5.0	4.4	

Standard errors

Marginal means within varieties 1) vertical ± 0.33

2) horizontal ± 0.24

Vertical means averaged over varieties ± 0.24

Within the body of the table:

All comparisons within variety ± 0.47

Table 5 - Effect of sprouting in the previous season and in the current season on sprouts > 8 mm. per tuber at planting time.

		ARRAN PILOT			MAJESTIC			
		Sprouting in the current season			Sprouting in the current season			
		Nov. (N^1)	Mar. (M^1)	Mean	Nov. (N^1)	Mar. (M^1)	Mean	Mean
Sprouting in the previous season	I	2.00	3.30	2.65	1.25	1.75	1.50	2.07
	A	1.95	3.48	2.71	1.25	1.50	1.38	2.04
	M	2.30	2.40	2.35	1.38	1.88	1.63	1.99
	O	2.90	2.90	2.90	1.58	1.83	1.70	2.30
Mean		2.29	3.02	2.65	1.36	1.74	1.55	

Standard errors

Marginal means within varieties 1) vertical ± 0.139

2) horizontal ± 0.098

Vertical means averaged over varieties ± 0.098

Within the body of the table:

All comparisons within variety ± 0.197

at both dates of sprouting although there was a greater loss of sprouts during storage in Majestic at the early date of sprouting (N^1) (figure 5).

3.1.3. <u>Sprouts > 8 mm at planting time</u> (table 5)

Not all sprouts on a tuber produce mainstems in the field. The number of mainstems in the field was found to be more closely related to the number of large well-developed sprouts >8 mm at planting time (J.C. Holmes, unpublished results).

There was no effect of the previous season's treatments (I, A, M, O) on the number of sprouts >8 mm per tuber at planting. In both varieties <u>March</u>-sprouting in the current season (M^1) produced a significantly greater number of sprouts >8 mm per tuber by planting time than <u>November</u>-sprouting (N^1).

3.1.4. <u>Sprout length</u> (table 6)

In Arran Pilot, but not in Majestic, there was a small but significant effect of the previous season's treatments (I, A, M, O) (figures 3 and 4) with <u>November</u>-sprouting in the current season (N^1) on total sprout length per tuber early in the sprouting phase, the two treatments I and A, sprouted in <u>November</u> of the previous season, resulting in a greater sprout length than M and O which behaved similarly. This effect was not evident with <u>March</u>-sprouting in the current season (M^1) and in the <u>November</u>-sprouted treatment (N^1) it had disappeared by the end of January.

There was little difference in total sprout length per

Figure 3 Effect of the previous season's treatments on the change in sprout length (mm.) with time when the tubers were set up to sprout in November of the current season.

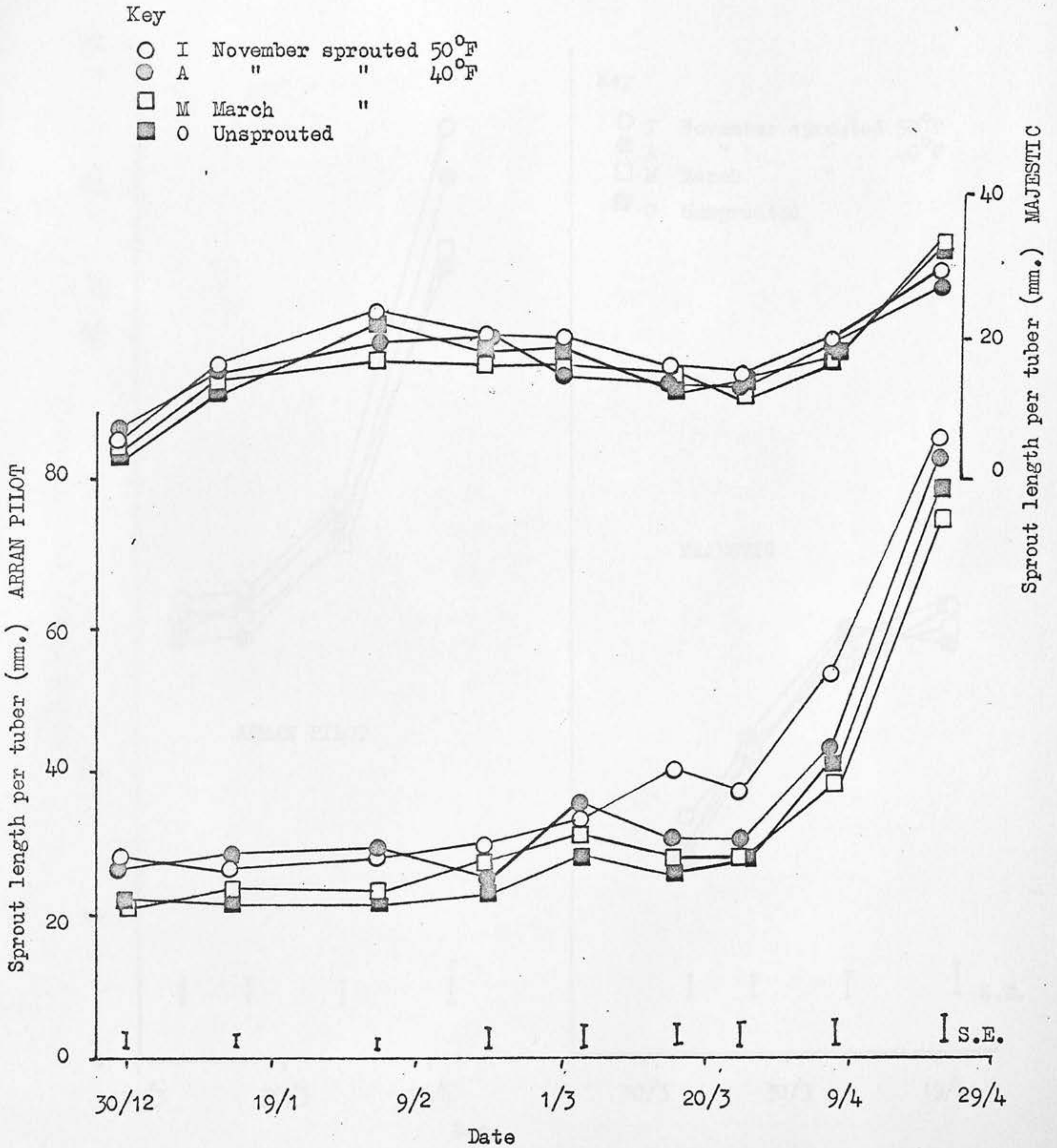
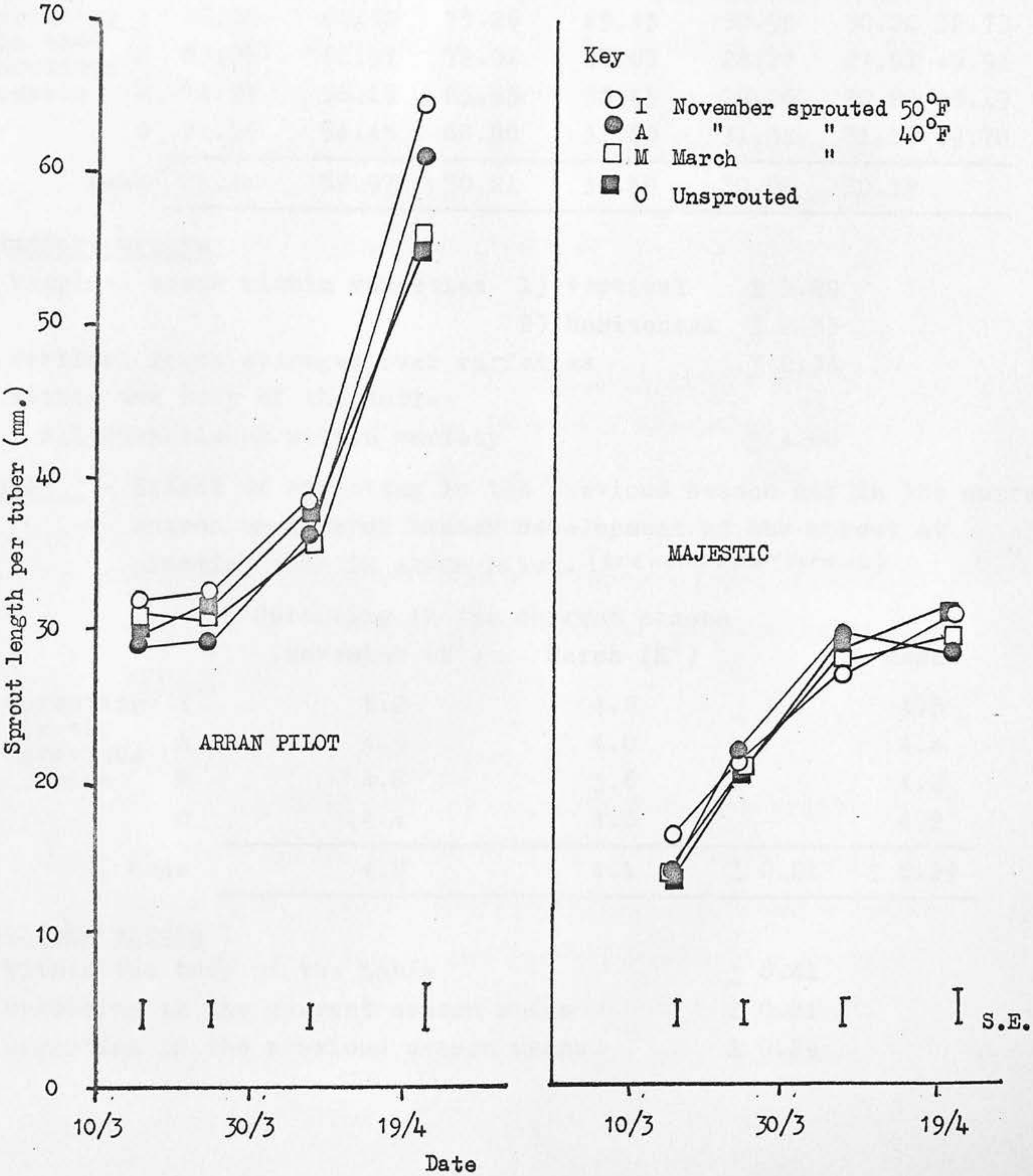


Figure 4 Effect of the previous season's treatments on the change in sprout length (mm.) with time when the tubers were set up to sprout in March of the current season.



<u>Table 6</u> - Effect of sprouting in the previous season and in the current season on sprout length per tuber (mm.) at planting time.

		ARRAN PILOT			MAJESTIC			
		Sprouting in the current season			Sprouting in the current season			
		Nov. (N^1)	Mar. (M^1)	Mean	Nov. (N^1)	Mar. (M^1)	Mean	Mean
Sprouting in the previous season	I	86.20	64.32	75.26	29.45	30.95	30.20	52.73
	A	83.05	60.97	72.01	27.05	28.77	27.91	49.96
	M	74.95	56.15	65.55	32.45	29.20	30.82	48.19
	O	81.55	54.45	68.00	31.80	31.32	31.56	49.78
Mean		81.44	58.97	70.21	30.19	30.06	30.12	

<u>Standard errors</u>

Marginal means within varieties 1) vertical ± 3.29

2) horizontal ± 2.33

Vertical means averaged over varieties ± 2.33

Within the body of the table:

All comparisons within variety ± 4.66

<u>Table 7</u> - Effect of sprouting in the previous season and in the current season on lateral branch development of the sprout at planting time in Arran Pilot. (branches per sprout)

		Sprouting in the current season			
		November (N^1)	March (M^1)		Mean
Sprouting in the previous season	I	5.2	4.8		4.5
	A	4.9	4.0		4.4
	M	4.8	3.6		4.2
	O	4.4	4.0		4.2
Mean		4.8	4.1	± 0.21	± 0.29

<u>Standard errors</u>

Within the body of the table ± 0.41

Sprouting in the current season means ± 0.21

Sprouting in the previous season means ± 0.29

tuber at planting time in Majestic between dates of sprouting in the current season but there was a large difference in Arran Pilot, November-sprouting in the current season (N^1) producing a greater sprout length per tuber. This was possibly due to the longer period of growth as a result of earlier bud growth in Arran Pilot than in Majestic. During a large part of the sprouting phase there was little growth of the sprouts in the November-sprouted treatments in either variety, but during April there was a rapid increase in sprout length (figure 6) which was associated with an increase in the temperature of the store.

3.1.5. Sprout development at planting time (table 7)

In Arran Pilot the sprouts were well developed with both dates of sprouting in the current season (N^1, M^1) though more so with November-sprouting (N^1). There was no significant effect of the previous season's treatments on sprout development. There was no lateral development of sprouts in Majestic at planting time.

3.1.6. Stem numbers (tables 8 and 9)

There was no effect of the previous season's treatments (I, A, M, O) on mainstem number or total stem number at ground level. There were, however, large differences in mainstem and total stem number produced by the current season's sprouting treatments. Unsprouted tubers (O^1) produced the greatest number of mainstems and November-sprouting (N^1) the least.

Figure 5 Effect of the current season's treatments on the change in sprout number with time.

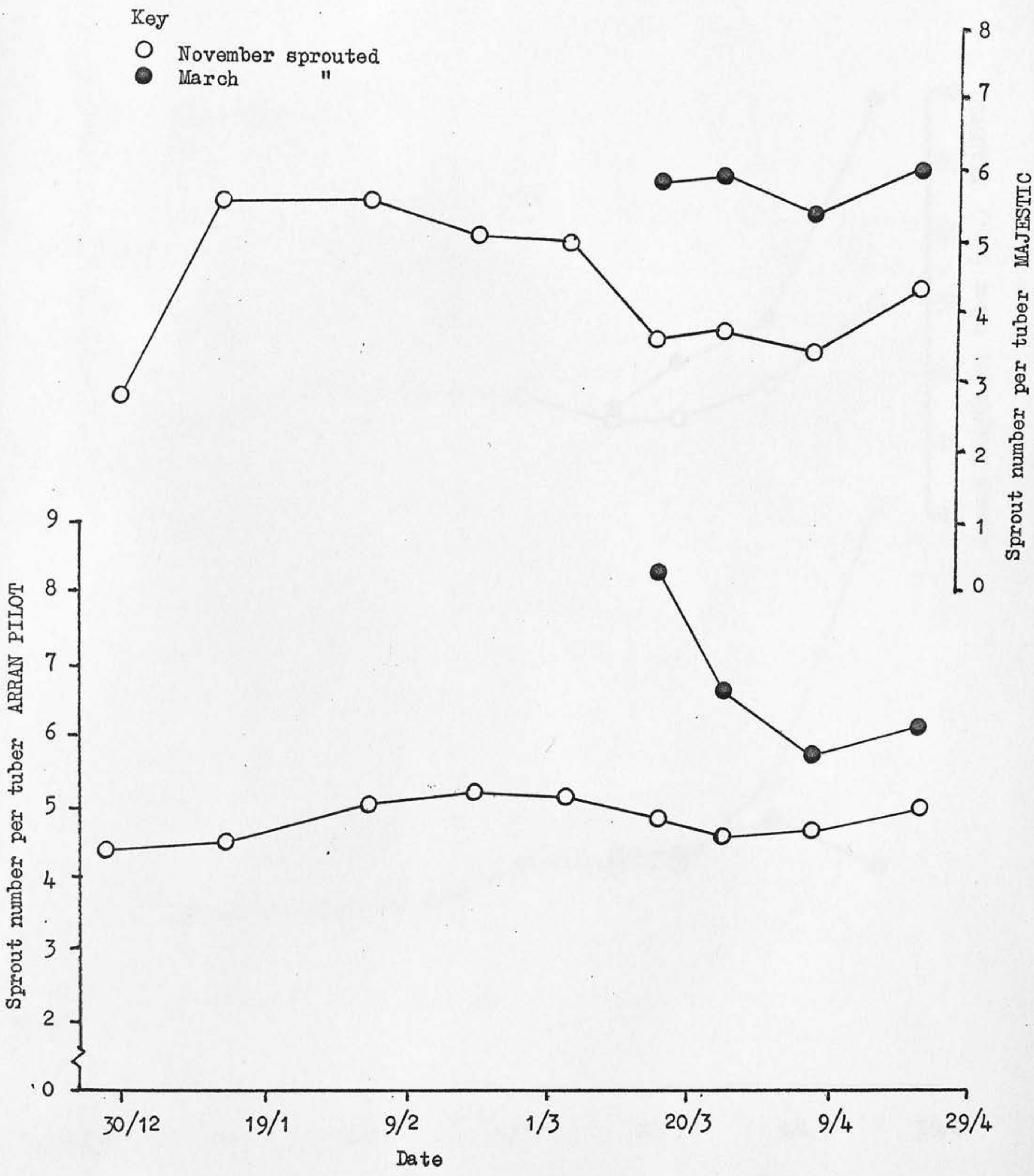


Figure 6 Effect of the current season's treatments on the change in sprout length (mm.) with time.

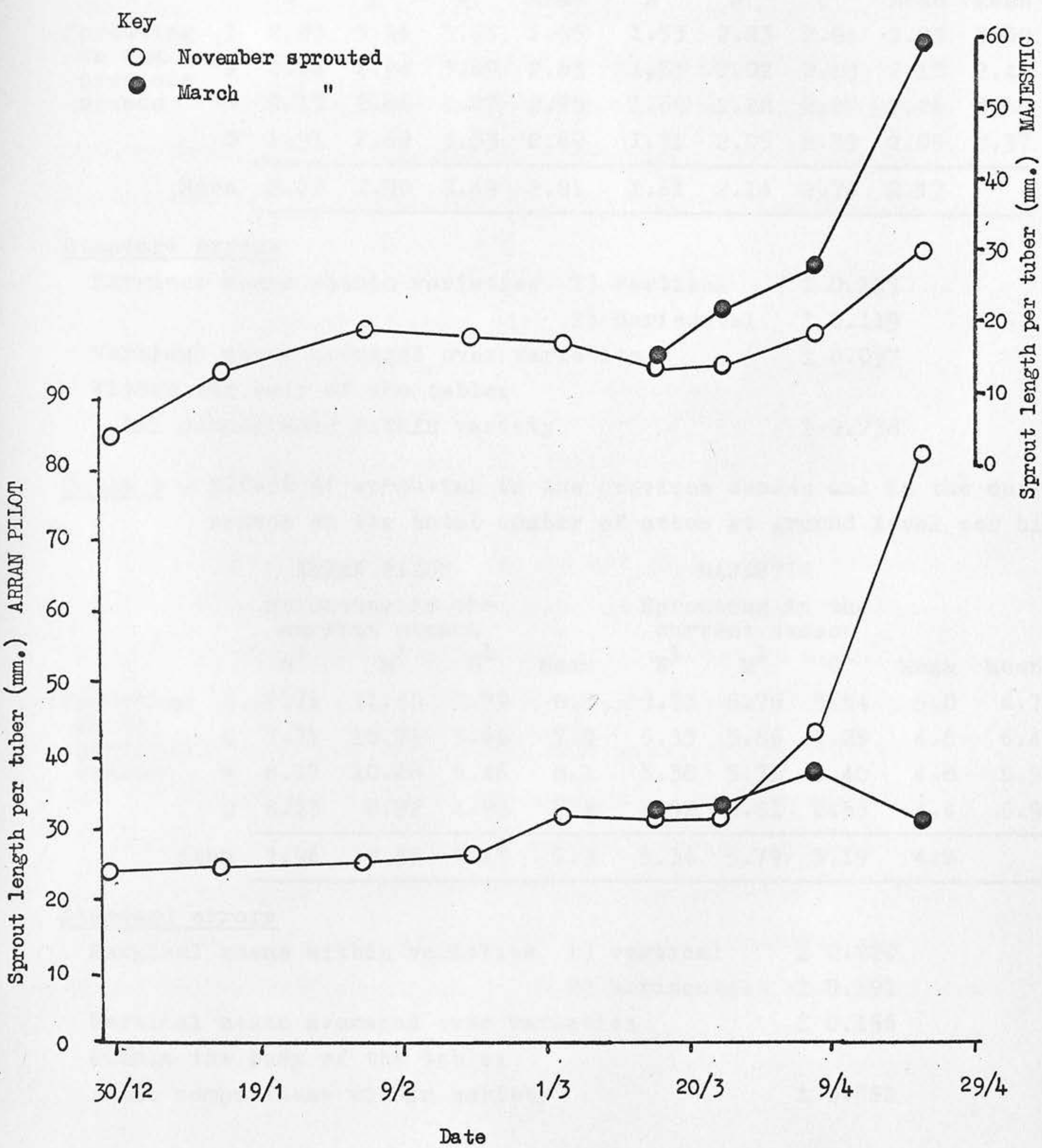


Table 8 - Effect of sprouting in the previous season and in the current season on mainstem number per hill.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	2.03	3.18	3.65	2.95	1.53	2.23	2.94	2.23	2.59
	A	2.06	2.94	3.49	2.83	1.53	2.02	2.83	2.13	2.48
	M	2.13	2.86	3.27	2.75	1.69	2.28	2.80	2.26	2.50
	O	1.91	2.62	3.53	2.69	1.71	2.05	2.39	2.05	2.37
Mean		2.03	2.90	3.49	2.81	1.61	2.14	2.74	2.17	

Standard errors

Marginal means within varieties 1) vertical ± 0.137

2) horizontal ± 0.119

Vertical means averaged over varieties ± 0.097

Within the body of the table:

All comparisons within variety ± 0.238

Table 9 - Effect of sprouting in the previous season and in the current season on the total number of stems at ground level per hill.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	7.71	11.40	5.79	8.3	5.73	5.78	3.54	5.0	6.7
	A	7.71	10.32	5.66	7.9	5.33	5.86	3.25	4.8	6.4
	M	8.17	10.68	5.46	8.1	5.38	5.71	3.40	4.8	5.9
	O	8.23	8.92	4.98	7.4	4.92	5.81	2.55	4.4	5.9
Mean		7.96	10.33	5.47	7.9	5.34	5.79	3.19	4.8	

Standard errors

Marginal means within varieties 1) vertical ± 0.220

2) horizontal ± 0.191

Vertical means averaged over varieties ± 0.156

Within the body of the table:

All comparisons within variety ± 0.382

Arran Pilot produced more mainstems at all dates of sprouting than Majestic but there was no evidence that the response to sprouting varied with variety. In both varieties there was little lateral branch development in unsprouted tubers, resulting in fewer total stems at ground level than sprouted tubers. There was no difference with Majestic in total stem number at ground level between the dates of sprouting, but in Arran Pilot, <u>March</u>-sprouting (M^1) produced a significantly greater number of total stems than <u>November</u>-sprouting (N^1).

3.1.7. <u>Relationships between sprout number, sprout development at planting time and stem numbers</u>

In both varieties March-sprouting (M^1) in the current season produced more sprouts and sprouts $>$ 8 mm at planting time and, in the field, more mainstems than November-sprouting (N^1).

Although the pattern of sprout and stem growth was not followed closely from marked tubers, an attempt was made to relate the variation in sprout and stem characters among the previous season's treatments. Correlation coefficients were calculated as an analysis within seed size, variety and the current season's treatments and among the previous season's treatments. Although mainstem number increased with an increase in sprout number at planting time and with an increase in the number of large sprouts per tuber, the correlations obtained were low and non-significant partly as a result of the small amount of variation in stem and sprout characteristics among the previous season's treatments. For sprout number and mainstem number r = 0.308 N.S., d.f. 8 in Arran Pilot and r = 0.109 N.S., d.f. 8 in Majestic and for sprouts $>$ 8 mm and mainstem number r = 0.074 N.S., d.f. 8 in Arran Pilot and r = 0.506 N.S., d.f. 8 in Majestic.

Goodwin (1964) has related the total number of stems at ground level to an index of sprout development at planting time (defined as the total number of stolons + lateral aerial branches + sprouts per tuber). In this experiment there was no lateral development of the sprouts in Majestic. In Arran Pilot an increase in the index of sprout development was associated with an increase in the total number of stems at ground level but the correlation was low (r = 0.26 N.S., d.f. 16).

3.2. Field Growth

3.2.1. General aspects of growth

The 1965 season was wet and cold during the early phases of growth (table 4 of the Appendix). Although emergence was slow and erratic there was little blanking. Towards the end of the season conditions were favourable for the spread of blight in the foliage which led in the unsprouted treatments (O^1) to premature loss of foliage and in all treatments to infection of the tubers. Coefficients of variation for a

Table 10 - Effect of sprouting in the current season and in the previous season on the time of 50% emergence (E), apparent tuber initiation (I) and 95% senescence (S).

	ARRAN PILOT			MAJESTIC		
	E	I	S	E	I	S
N^1	27 May	1 July	1 Sept.	30 May	1 July	22 Sept.
M^1	29 May	3 July	1 Sept.	30 May	2 July	22 Sept.
O^1	6 June	8 July	4 Sept.	10 June	9 July	29 Sept.
I	31 May	-	1 Sept.	2 June	-	23 Sept.
A	30 May	-	30 Aug.	2 June	-	23 Sept.
M	1 June	-	1 Sept.	2 June	-	22 Sept.
O	30 May	-	30 Aug.	3 June	-	25 Sept.

Table 11 - Effect of sprouting in the current season on the number of days from planting to emergence (P), planting to apparent tuber initiation (T), emergence to apparent tuber initiation (E) and the length of the bulking period (from apparent tuber initiation to senescence) (B).

	ARRAN PILOT				MAJESTIC			
	P	T	E	B	P	T	E	B
N^1	33	68	35	71	36	67	31	83
M^1	35	70	35	69	36	68	32	82
O^1	43	75	32	68	47	76	29	82

number of attributes at final harvest were between 8% and 15% of the plot mean.

The effect of treatment on the dates of 50% emergence, apparent tuber initiation and 95% senescence are shown in tables 10 and 11. There was no effect of the previous season's treatments (I, A, M, O) on these attributes. The time of emergence and apparent tuber initiation was similar in both varieties, but the date of senescence was later in Majestic than Arran Pilot. The tubers from the sprouted treatments (N^1, M^1) of the current season, which showed little difference in the time to 50% emergence or 95% senescence, emerged 8-10 days and matured 4-7 days earlier than the unsprouted treatment (O^1). There was little difference between the treatments (N^1, M^1) in the time of apparent tuber initiation but they initiated tubers 5-7 days earlier than the unsprouted tubers (O^1).

3.2.2. Total tuber yield and total tuber number (tables 12 and 18)

There was no effect of the previous season's treatments (I, A, M, O) on total tuber yield or total tuber number. There were, however, large effects arising from sprouting in the current season. In both Arran Pilot and Majestic, total tuber yields were similar for the two sprouted treatments (N^1, M^1) and significantly greater than the unsprouted treatments (about 1.5 tons per acre in Arran Pilot and 2.0 tons per acre

Table 12 - Effect of sprouting in the previous and the current seasons on total tuber yield at harvest (tons per acre).

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	13.21	12.83	11.65	12.56	16.42	16.54	14.25	15.74	14.15
	A	13.30	13.72	11.58	12.86	15.07	15.49	13.84	14.80	13.83
	M	13.52	13.89	12.01	13.14	16.49	14.83	13.08	14.80	13.97
	O	12.43	12.71	11.70	12.28	16.34	14.82	13.19	14.78	13.53
Mean		13.11	13.29	11.74	12.71	16.08	15.42	13.59	15.03	

Standard errors

Marginal means within varieties	1) vertical	± 0.346
	2) horizontal	± 0.300
Vertical means averaged over varieties		± 0.245
Within the body of the table:		
All comparisons within variety		± 0.600

Table 13 - Effect of sprouting in the previous and in the current seasons on ware yield ($> 2\frac{1}{4}$") at harvest (tons per acre).

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	5.35	3.73	2.50	3.86	6.51	7.95	5.22	6.56	5.21
	A	4.94	3.65	2.70	3.76	6.56	7.46	5.79	6.60	5.18
	M	5.20	4.40	2.68	4.09	8.39	6.79	5.38	6.85	5.47
	O	4.66	2.91	2.57	3.38	7.87	6.95	5.45	6.76	5.07
Mean		5.04	3.67	2.61	3.77	7.33	7.29	5.46	6.69	

Standard errors

Marginal means within varieties	1) vertical	± 0.286
	2) horizontal	± 0.247
Vertical means averaged over varieties		± 0.202
Within the body of the table:		
All comparisons within variety		± 0.495

Table 14 - Effect of variety and sprouting in the previous and in the current seasons on large seed yield ($1\frac{3}{4}$"– $2\frac{1}{4}$") at harvest (tons per acre).

		ARRAN PILOT Sprouting in the current season				MAJESTIC Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	2.73	2.39	2.16	2.43	4.01	3.65	3.99	3.88	3.16
	A	2.98	3.24	2.73	2.98	3.86	3.45	3.34	3.55	3.27
	M	3.04	2.75	2.86	2.88	3.60	3.60	3.14	3.45	3.16
	O	3.24	2.55	2.55	2.78	3.78	3.19	3.27	3.41	3.10
	Mean	3.00	2.73	2.57	2.77	3.81	3.47	3.43	3.57	

Standard errors

Marginal means within varieties	1) vertical	± 0.170
	2) horizontal	± 0.147
Vertical means averaged over varieties		± 0.120
Within the body of the table:		
All comparisons within variety		± 0.295

Table 15 - Effect of sprouting in the previous season and in the current season on small seed yield ($1\frac{1}{4}$"–$1\frac{3}{4}$") at harvest (tons per acre).

		ARRAN PILOT Sprouting in the current season				MAJESTIC Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	4.94	6.43	6.64	6.00	5.63	4.73	4.84	5.07	5.54
	A	5.15	6.53	5.89	5.86	4.48	4.42	4.50	4.47	5.16
	M	4.96	6.43	6.25	5.88	4.37	4.30	4.37	4.35	5.11
	O	4.35	6.87	6.33	5.85	4.58	4.55	4.30	4.48	5.16
	Mean	4.85	6.57	6.28	5.90	4.77	4.50	4.50	4.59	

Standard errors

Marginal means within varieties	1) vertical	± 0.252
	2) horizontal	± 0.218
Vertical means averaged over varieties		± 0.178
Within the body of the table:		
All comparisons within variety		± 0.224

Table 16 - Effect of sprouting in the previous season and in the current season on total seed yield ($1\frac{1}{4}"-2\frac{1}{4}"$) at harvest (tons per acre).

		ARRAN PILOT Sprouting in the current season				MAJESTIC Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	7.67	8.82	8.80	8.43	9.65	8.39	8.82	8.95	8.69
	A	8.13	9.78	8.62	8.84	8.33	7.87	7.85	8.02	8.43
	M	8.00	9.18	9.11	8.76	7.97	7.90	7.51	7.79	8.28
	O	7.59	9.42	8.88	8.63	8.36	7.74	7.56	7.89	8.26
	Mean	7.85	9.30	8.85	8.67	8.58	7.97	7.94	8.16	

Standard errors

Marginal means within varieties 1) vertical ± 0.294

2) horizontal ± 0.254

Vertical means averaged over varieties ± 0.208

Within the body of the table:

All comparisons within variety ± 0.509

Table 17 - Effect of sprouting in the previous season and in the current season on chat yield ($< 1\frac{1}{4}"$) at harvest (tons per acre).

		ARRAN PILOT Sprouting in the current season				MAJESTIC Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	0.19	0.28	0.35	0.27	0.26	0.20	0.21	0.22	0.25
	A	0.23	0.29	0.26	0.26	0.18	0.15	0.21	0.18	0.22
	M	0.33	0.31	0.23	0.29	0.13	0.14	0.19	0.15	0.22
	O	0.18	0.39	0.25	0.28	0.11	0.13	0.17	0.14	0.21
	Mean	0.23	0.32	0.27	0.27	0.17	0.16	0.19	0.17	

Standard errors

Marginal means within varieties 1) vertical ± 0.020

2) horizontal ± 0.014

Vertical means averaged over varieties ± 0.014

Within the body of the table:

All comparisons within variety ± 0.041

Table 18 - Effect of sprouting in the previous season and in the current season on the total number of tubers per acre at harvest.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	131,832	175,276	153,957	153,688	157,645	147,965	139,898	148,503	151,096
	A	138,169	161,102	145,775	148,349	139,783	137,594	131,371	136,249	142,299
	M	152,459	162,484	146,006	153,650	135,058	125,724	124,456	128,413	141,031
	O	140,820	165,366	145,660	150,615	139,322	136,441	122,728	132,830	141,723
Mean		140,820	166,057	147,850	151,576	142,952	136,931	129,613	136,499	

Standard errors

Marginal means within varieties 1) vertical ± 5348

2) horizontal ± 4631

Vertical means averaged over varieties ± 3781

Within the body of the table:

All comparisons within variety ± 9262

Table 19 - Effect of sprouting in the previous season and in the current season on the number of ware tubers ($>2\frac{1}{4}$") per acre at harvest.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	25,698	19,360	13,944	19,667	31,690	37,798	25,467	31,652	25,660
	A	23,854	19,244	16,364	19,821	31,229	34,686	27,657	31,191	25,506
	M	24,776	22,241	14,981	20,665	38,605	28,579	25,928	31,037	25,852
	O	22,933	15,557	14,059	17,516	36,069	33,765	26,159	31,998	24,757
Mean		24,315	19,100	14,837	19,417	34,398	33,707	26,303	31,469	

Standard errors

Marginal means within varieties	1) vertical	± 1290.0
	2) horizontal	± 1117.0
Vertical means averaged over varieties		± 912.2
Within the body of the table:		
All comparisons within variety		± 2234.0

Table 20 - Effect of sprouting in the previous season and in the current season on the number of large seed tubers ($1\frac{3}{4}$"-$2\frac{1}{4}$") per acre at harvest.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	20,973	19,245	18,553	19,590	30,192	27,887	30,999	29,693	24,642
	A	22,702	25,006	22,241	23,316	30,077	26,505	26,044	27,542	25,429
	M	22,010	21,549	22,356	21,972	27,426	27,311	24,661	26,466	24,219
	O	21,088	20,051	20,627	20,589	29,386	25,237	25,698	26,774	23,681
Mean		21,693	21,463	20,944	21,367	29,270	26,735	26,850	27,619	

Standard errors

Marginal means within varieties	1) vertical	± 1212
	2) horizontal	± 1049
Vertical means averaged over varieties		± 857
Within the body of the table:		
All comparisons within variety		± 2099

Table 21 - Effect of sprouting in the previous season and in the current season on the number of small seed tubers ($1\frac{1}{4}$"-$1\frac{3}{4}$") per acre at harvest.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	75,826	120,423	103,829	100,026	80,897	69,719	72,600	74,405	87,216
	A	80,205	100,948	92,997	91,383	68,451	67,644	67,414	67,836	79,610
	M	87,465	102,331	96,454	95,417	63,150	62,343	63,842	63,112	79,264
	O	86,889	107,977	97,606	97,491	67,990	67,068	61,882	65,647	81,569
Mean		82,596	107,920	97,721	96,079	70,122	66,693	66,434	67,750	

Standard errors

Marginal means within varieties 1) vertical ± 4904

2) horizontal ± 4247

Vertical means averaged over varieties ± 3003

Within the body of the table:

All comparisons within variety ± 8496

Table 22 - Effect of sprouting in the previous season and in the current season on the total number of seed tubers ($1\frac{1}{4}$"-$2\frac{1}{4}$") per acre at harvest.

		ARRAN PILOT				MAJESTIC				
		Sprouting in the current season				Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	96,799	139,668	122,382	119,616	111,089	97,606	103,598	104,098	111,857
	A	102,907	125,955	115,237	114,699	98,528	94,149	93,458	95,378	105,039
	M	109,476	123,880	118,810	117,389	90,577	89,655	88,502	89,578	103,483
	O	107,977	128,029	118,234	118,080	97,376	92,305	87,580	92,420	105,250
Mean		104,290	129,383	118,666	117,446	99,392	93,429	93,285	95,369	

Standard errors

Marginal means within varieties	1) vertical	± 5011
	2) horizontal	± 4340
Vertical means averaged over varieties		± 3543
Within the body of the table:		
All comparisons within variety		± 8680

Table 23 - Effect of sprouting in the previous season and in the current season on the number of chats per acre at harvest.

		ARRAN PILOT Sprouting in the current season				MAJESTIC Sprouting in the current season				
		N^1	M^1	O^1	Mean	N^1	M^1	O^1	Mean	Mean
Sprouting in the previous season	I	9,334	16,248	17,631	14,405	14,866	12,561	10,832	12,753	13,579
	A	11,408	15,903	14,174	13,828	10,026	8,758	10,256	9,680	11,754
	M	18,207	16,364	12,215	15,595	5,877	7,490	10,025	7,798	11,697
	O	9,910	21,780	13,367	15,019	5,877	10,026	8,988	8,412	11,716
Mean		12,215	17,574	14,347	14,712	9,161	9,795	10,025	9,661	

Standard errors

Marginal means within varieties 1) vertical	± 1289
2) horizontal	± 1116
Vertical means averaged over varieties	± 912
Within the body of the table:	
All comparisons within variety	± 2233

in Majestic).

Majestic showed little response in tuber number to sprouting in the current season though there was a tendency for the November-sprouted treatment (N^1) to produce more tubers than the March-sprouted treatment (M^1) or the unsprouted treatment (O^1). On the other hand Arran Pilot showed larger differences in tuber number in response to sprouting. The March-sprouted treatment (M^1) produced a significantly greater number of tubers than either the unsprouted (O^1) $\triangleq$ 13% or the November-sprouted (N^1) treatment $\triangleq$ 19%.

3.2.3. <u>Graded tuber yields and tuber numbers</u> (tables 13, 14, 15, 16, 17, 19, 20, 21, 22, 23)

There was no effect of the previous season's treatment on graded tuber yields or numbers. There was little response in Majestic in either the yield or number of tubers in the various grades to the current season's treatments, largely as a result of the small effect of the treatments on total yield and tuber number. The reduction in total yield in the unsprouted treatments did, however, result in a significant reduction in ware yield and in the number of ware-sized tubers compared with the sprouted treatments. In Arran Pilot, although both <u>November</u>- and <u>March</u>-sprouted tubers produced a similar total yield of tubers, the larger total number of tubers in the March-sprouting treatment resulted in a greater yield of seed. This was due to a greater yield of small seed, and a smaller yield of ware. In the unsprouted treatment the reduction in total yield resulted, compared with the November-sprouted treatment, in a reduction in ware yield and an increase in the small seed and total seed yield. In comparison with the March-sprouting treatment this reduction in ware yield was not accompanied by an increase in seed yield since the unsprouted treatment produced fewer tubers. Tuber numbers in the various grades followed the pattern of grading by weight closely.

3.2.4. Relationships between stem numbers and tuber numbers

The number of tubers was not closely related to either the number of mainstems or total stems in Arran Pilot. In Majestic there was an increase in tuber number with a decrease in mainstem numbers thus showing an opposite trend to the results of previous years (J.C. Holmes, unpublished results - table 1). Moorby and McGee (1966) and Ali (1968) have indicated that the condition of 'coiled-sprout', which was severe in the sprouted treatments in this experiment (table 24), can result in an increase in the number of lateral aerial branches and tubers. In this experiment, lateral branches arising from mainstems, which had coiled and not emerged, produced stolons and formed tubers. To test whether the failure of the terminal bud to emerge, with the resulting branching, had any effect on tuber number, a multiple regression of tuber number (Y) on total mainstem number (X_1) and on mainstems emerging only by the lateral branches (X_2)

Table 24 - Effect of sprouting in the current season on the number of mainstems which emerged by the terminal shoot (E) and the number which emerged only by lateral branches (B) - average of 3 hills over sample lifts 3 and 4.

	ARRAN PILOT				MAJESTIC			
	E	B	% of the total showing 'coiled-sprout'	Total	E	B	% of the total showing 'coiled-sprout'	Total
November	4.1	2.1	34%	6.2	3.6	1.1	23.4%	4.7
March	4.3	4.3	50%	8.6	4.2	2.0	32.3%	6.2

was made on the data from sample lifts 3 and 4 pooled within variety, seed size and treatment. This resulted in the equation

$$Y = 31.1 + 2.60\ X_1 + 1.84\ X_2$$

$$\text{S.E. } b_1 = \pm\ 0.65; \quad b_2 = \pm\ 0.82$$

Both regression coefficients were significant. Though the equation accounted for only 20% of the variance in total tuber number it indicates that tuber number rose with an increase in mainstem number, and that mainstems emerging only by the lateral branches produced a smaller but additional increase.

3.3. Growth Analysis

Only the data for the current year's sprouting treatments are presented here averaged over the previous season's treatments, seed size and replicate. There was no effect of the previous year's treatments (I, A, M, O) on either the development of tuber yield, the development of tuber number, total dry matter production or foliage growth, and the data is given in the Appendix (tables 7-11) as an average over the current season's treatments, seed size and replicate.

3.3.1. Development of tuber number (figure 7)

Maximum tuber number was reached about 2 weeks after the beginning of tuber formation but this appeared to occur slightly earlier relative to the time of tuber initiation in Majestic. Thereafter in both varieties, there was a slight

Figure 7 Effect of the current season's treatments on the change in tuber number with time.

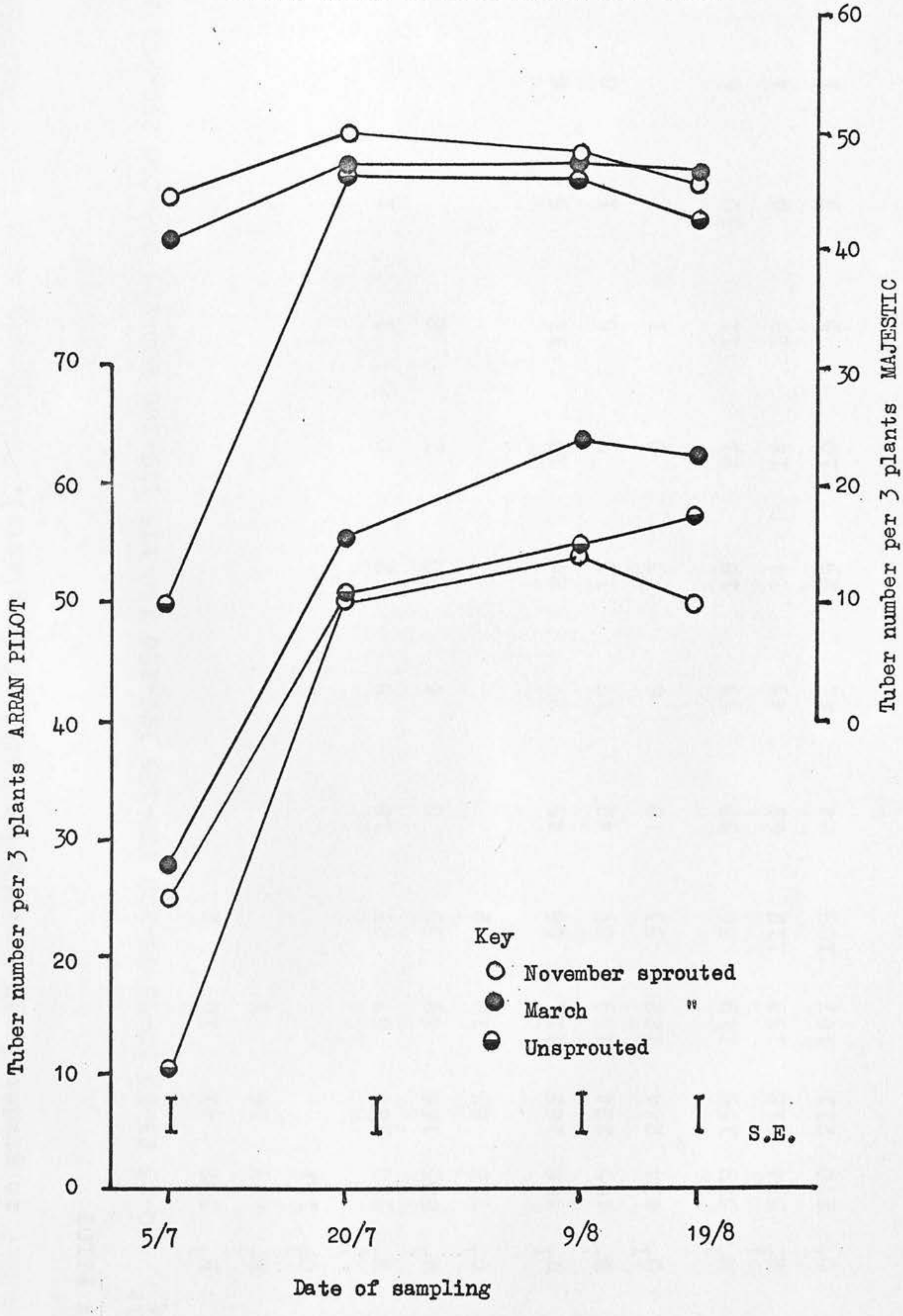


Table 25 - Effect of the date of sampling and sprouting in the current season on the number of tubers in grades (each treatment a total of 24 plants).

ARRAN PILOT

Sample lift		0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200	200-225	225-250	250-275	275-300	>300g
	N^1	352	41	10	2									
2	M^1	429	16	1										
	O^1	152												
	N^1	528	167	67	25	18	8	2	0	1	1			
3	M^1	605	166	69	35	8	4	0	1	2				
	O^1	716	85	10	2									
	N^1	366	162	114	66	45	27	24	18	11	5	6	6	2
4	M^1	465	224	159	89	42	17	11	7	5	1	0	1	0
	O^1	414	244	122	53	18	8	3	0	1				
	N^1	329	159	119	86	58	53	18	21	11	10	6	10	12
5	M^1	334	218	153	112	62	43	34	14	15	6	4	6	
	O^1	270	211	167	109	84	41	29	10	3	3	1	0	1

Table 25 (contd.)

MAJESTIC

Sample lift		0-25	25-50	50-75	75-100	100-125	125-150	150-175	175-200	200-225	225-250	250-275	275-300	>300g
	N[1]	670	11	4	1									
2	M[1]	652	10											
	O[1]	158												
	N[1]	427	191	106	39	21	2	4						
3	M[1]	475	158	71	39	10	3	2						
	O[1]	699	36	-	-	1								
	N[1]	267	127	126	97	71	38	25	14	3	1			
4	M[1]	291	127	107	93	60	44	25	11	2	2	1		
	O[1]	407	165	107	39	7	6	2						
	N[1]	158	105	86	84	85	60	45	30	30	23	5	4	2
5	M[1]	202	99	82	113	69	65	41	19	17	5	3	4	2
	O[1]	212	133	105	80	63	44	19	11	4	7			

but continuous drop in tuber number to harvest. Tuber numbers in the various grades greater than 25 g either remained steady or showed an increase but there was a considerable fall in tuber number with time in the 0-25 g range (table 25). Part of this would account for the loss in total tuber number with time but most of the loss from this grade can be ascribed to growth of these tubers. Those treatments which initiated the most tubers produced the greatest number of tubers at harvest.

3.3.2. Development of tuber yield (figure 8)

Linear regressions of the form Y = a + b X were fitted to the fresh weight data for the means of the current season's treatments and the lines obtained extrapolated back to zero fresh weight to give a time of apparent tuber initiation. The slope of the line provided an estimate of the bulking rate (table 26).

There was little difference in either variety between the two sprouting (N^1, M^1) treatments in bulking rate or in the time of apparent tuber initiation. Unsprouted tubers in both varieties, however, showed a much slower bulking rate. It was apparent from graphs of tuber fresh weight with time that bulking in the unsprouted lots of both varieties was not strictly linear contrary to the results of Borah and Milthorpe (1959) and Radley et al. (1961). Early in the bulking phase in the unsprouted treatments, haulm growth was retarded (see section 3.3.5) and bulking rates were low although later in the season the rate of bulking did increase, suggesting a curvilinear relationship of tuber fresh weight with time. A complete analysis of variance on log-transformed tuber fresh weight data, including all the treatments, with sampling date included as an extra main plot factor, was carried out to separate the linear, quadratic and cubic components of increase in tuber fresh weight with time. There was no evidence of any effect of the previous season's treatments on tuber fresh weight or the interaction of this with other factors and these were pooled, resulting in the simplified Analysis of Variance in table 27 (where A = pooled sum of squares for factors non-significant by the F-test in the full Analysis of Variance table). Data are presented as back-transformed means in table 28 (log-transformed means and their standard errors are presented in brackets). There was no evidence of an interaction between sampling date, variety and sprouting in the current season. Both the linear and quadratic components over the samplings for sprouting in the current season were significant, the linear component removing 70% of the variation in the sum of squares for sprouting in the current season. The cubic component proved to be non-significant. From the table of effects it can be seen that most of the quadratic effect was located in the unsprouted crop and was significantly greater than in the sprouted crops, which showed little difference in their pattern of accumulation of tuber fresh weight. Dry weights followed fresh weights closely (table 29).

Figure 8 Effect of the current season's treatments on the change in tuber fresh weight with time.

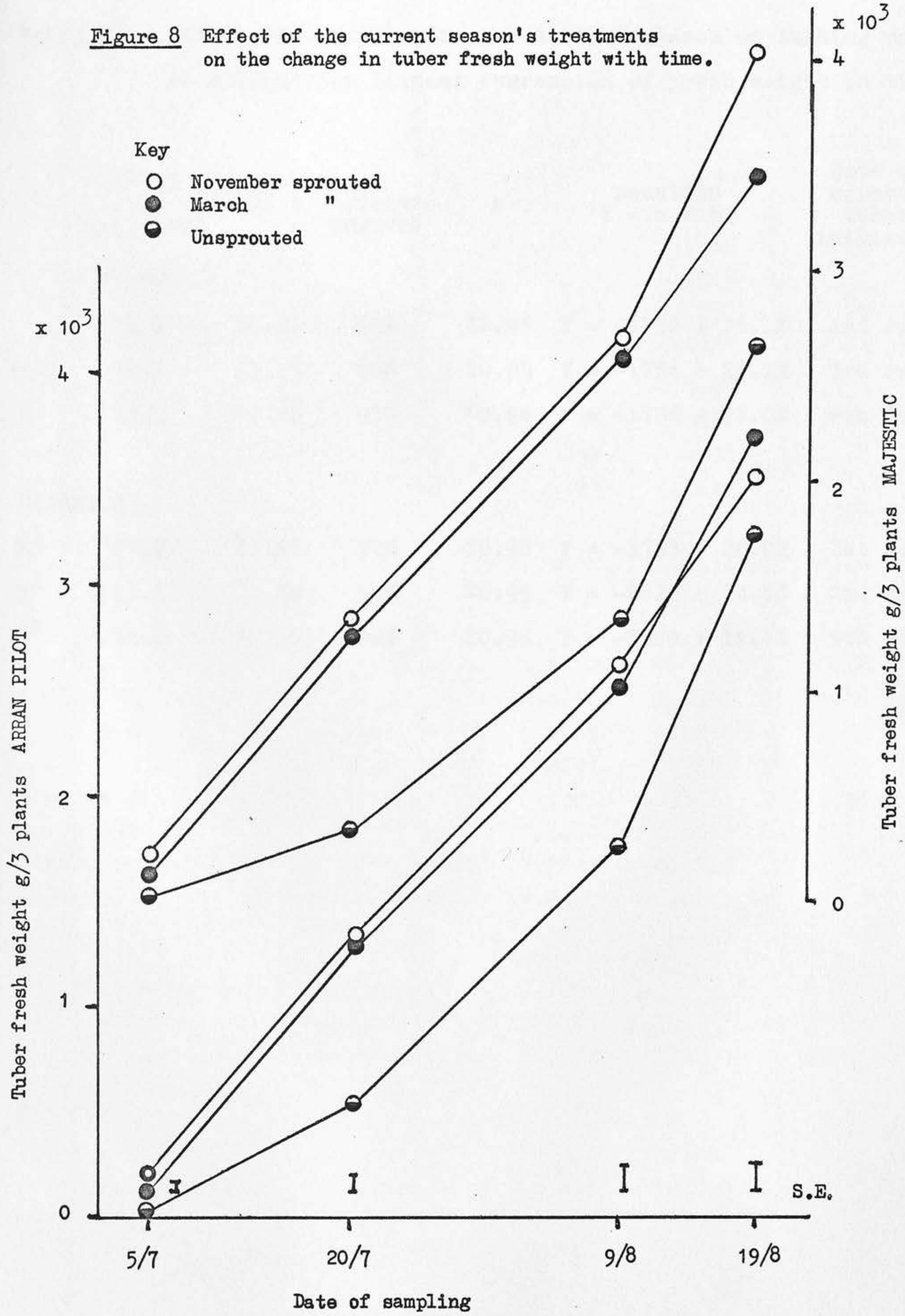


Table 26 - Effect of sprouting in the current season on bulking rate in g/plant/day (linear regression of fresh weight on time).

	Bulking rate (g/pl/day)	SE b	% variance removed	r	Equation $Y = a + bX$	Date of apparent tuber initiation
ARRAN PILOT						
N^1	25.1	±1.69	99%	±0.98	$Y = -1752 + 25.1X$	1st July
M^1	25.1	±3.37	98%	±0.99	$Y = -1754 + 25.1X$	3rd July
O^1	23.0	±6.46	93%	±0.96	$Y = -1706 + 23.0X$	8th July
MAJESTIC						
N^1	26.0	±4.83	97%	±0.98	$Y = -1753 + 26.0X$	1st July
M^1	23.6	±1.38	99%	±0.99	$Y = -1622 + 23.6X$	2nd July
O^1	18.4	±6.25	90%	±0.95	$Y = -1389 + 18.4X$	9th July

Table 27 - Analysis of variance of log transformed data for total tuber fresh weight.

	d.f.	SS	MS	F
Blocks	1	0.4689	0.4689	23.45 *
Sample lifts (L)	3	192.5981	64.1994	3208.9 **
Error 1	3	0.0600	0.0200	
Variety (V)	1	0.0652	0.0652	<1
L x V L Linear x V	3	0.1758	0.0586	<1
Size	1	3.7065	3.7065	31.28 **
Effect 1	1)	1.2742	1.2742	10.75 **
L x S	2)	0.0157	0.0079	<1
V x S	1	0.0551	0.0551	<1
L x V x S	3	0.0752	0.0251	<1
Error 2	12	1.4223	0.1185	
Sprouting in the current season (B)	2	22.3062	11.1531	198.45 **
Effect 2 L Linear x B	2	13.7527	6.8764	122.35 **
Effect 3 L Quadratic x B	2	1.3338	0.6669	11.86 **
L x B	2	0.2400	0.1200	2.13 NS
V x B	2	0.6030	0.3015	5.36 **
L x V x B	6	0.1425	0.0238	<1
S x B	2	0.0791	0.0396	<1
L x S x B	6	0.3988	0.0665	1.18 NS
V x S x B	2	0.0036	0.0018	<1
A (remainder)	150	7.7633	0.0518	<1
Error 3	176	9.8885	0.0562	
Total	383	256.4285	0.6695	

Standard error per 1) whole plot 0.71%

2) sub plot 3.47%

3) sub sub plot 8.27%

Effects

1.	L x S	0.03			±0.01
2.	L x B Linear	0.29	0.31	0.53	±0.012
3.	L x B Quadratic	-0.02	-0.02	-0.04	±0.003

Table 28 - Effect of date of sampling and date of sprouting in the current season on tuber fresh weight (g/3 plants). (Values given as back-transformed means. Log-transformed data with standard errors are shown in brackets.)

Sample lift	November	March	Unsprouted	Mean
		ARRAN PILOT		
2	133.9 (2.13)	96.7 (1.99)	7.1 (0.91)	46.9 (1.68)
3	1258.0 (3.10)	1229.0 (3.09)	523.8 (2.72)	932.3 (2.47)
4	2290.0 (3.36)	2511.0 (3.40)	1697.0 (3.23)	2137.0 (3.33)
5	3466.0 (3.54)	3714.0 (3.57)	3235.0 (3.51)	3466.0 (3.54)
Mean	1071.0 (3.03)	1022.0 (3.01)	388.0 (2.59)	757.6 (2.88)
		MAJESTIC		
2	146.9 (2.17)	122.0 (2.09)	6.8 (0.89)	51.5 (1.72)
3	1412.0 (3.15)	1121.0 (3.05)	294.1 (2.47)	775.2 (2.89)
4	2569.0 (3.41)	2454.0 (3.39)	1201.0 (3.08)	1949.0 (3.29)
5	3980.0 (3.60)	3387.0 (3.53)	2511.0 (3.40)	3235.0 (3.51)
Mean	1229.0 (3.09)	1046.0 (3.02)	287.4 (2.46)	706.9 (2.85)
Mean 2	140.3 (2.15)	108.6 (2.04)	6.9 (0.90)	49.1
Mean 3	1348.0 (3.13)	1174.0 (3.07)	397.1 (2.60)	850.1
Mean 4	2454.0 (3.39)	2454.0 (3.39)	1444.0 (3.16)	2041.0
Mean 5	3714.0 (3.57)	3547.0 (3.55)	2817.0 (3.45)	3310.0
Mean	1147.0 (3.06)	1022.0 (3.01)	337.8 (2.53)	740.3 (2.87)

Standard errors for log transformed values

A. Vertical marginal means averaged over variety and sprouting			± (0.014)
B. Marginal means within variety	1) horizontal		± (0.030)
	2) vertical		± (0.038)
C. Marginal means between varieties	1) horizontal		± (0.035)
	2) vertical		± (0.038)
D. Body of the table:	averaged over variety		± (0.037)
E. Do. :	within variety		± (0.019)

Table 29 - Effect of sprouting in the current season and date of sampling on tuber dry matter yields (g/3 plants).

	ARRAN PILOT			
	Lift 2	Lift 3	Lift 4	Lift 5
November sprouted	29.5	203.4	442.6	648.3
March sprouted	21.3	191.5	408.9	659.9
Unsprouted	2.5	76.6	275.6	574.9
S.E.	± 3.52	± 11.04	± 18.42	± 24.01
	MAJESTIC			
	Lift 2	Lift 3	Lift 4	Lift 5
November sprouted	40.8	245.3	441.9	748.7
March sprouted	25.3	193.3	421.9	619.1
Unsprouted	2.0	44.4	215.7	449.8
S.E.	± 3.52	± 11.04	± 18.42	± 24.01
	5/6 July	19/20 July	9/10 August	19/20 August

3.3.3. Rate of dry matter accumulation

The increase in total dry weight (foliage dry weight + tuber dry weight) with time is shown in figure 9 plotted as $\log_e$ total dry weight. It was assumed that at 50% emergence the total dry weight was zero (Bremner and Radley, 1966) and the graphs have been extrapolated back to this point. Throughout the season, both varieties showed similar growth rates, which gradually declined after the middle of June. In both varieties the treatments N^1, M^1 and O^1 showed a similar behaviour up to the 4th sample lift but after this the unsprouted lots (O^1) showed an increase in the growth rate whilst there was little change in the growth rate in the two sprouted lots (N^1 and M^1).

3.3.4. Partition of dry matter (figure 10)

The partition of dry matter between shoot and tuber has been considered at similar stages of growth by plotting haulm dry weight and tuber dry weight against total dry weight (Brouwer, 1962). In both varieties the reciprocal effects of shoot and tuber growth can be clearly seen. However, in Arran Pilot more dry matter entered the tubers than in Majestic in the early stages of growth. There was a tendency in both varieties for more dry matter to enter the foliage early in the season in the unsprouted O^1 than in the sprouted treatments (N^1, M^1).

Figure 9 Effect of the current season's treatments on the change in $\log_e$ total dry weight with time.

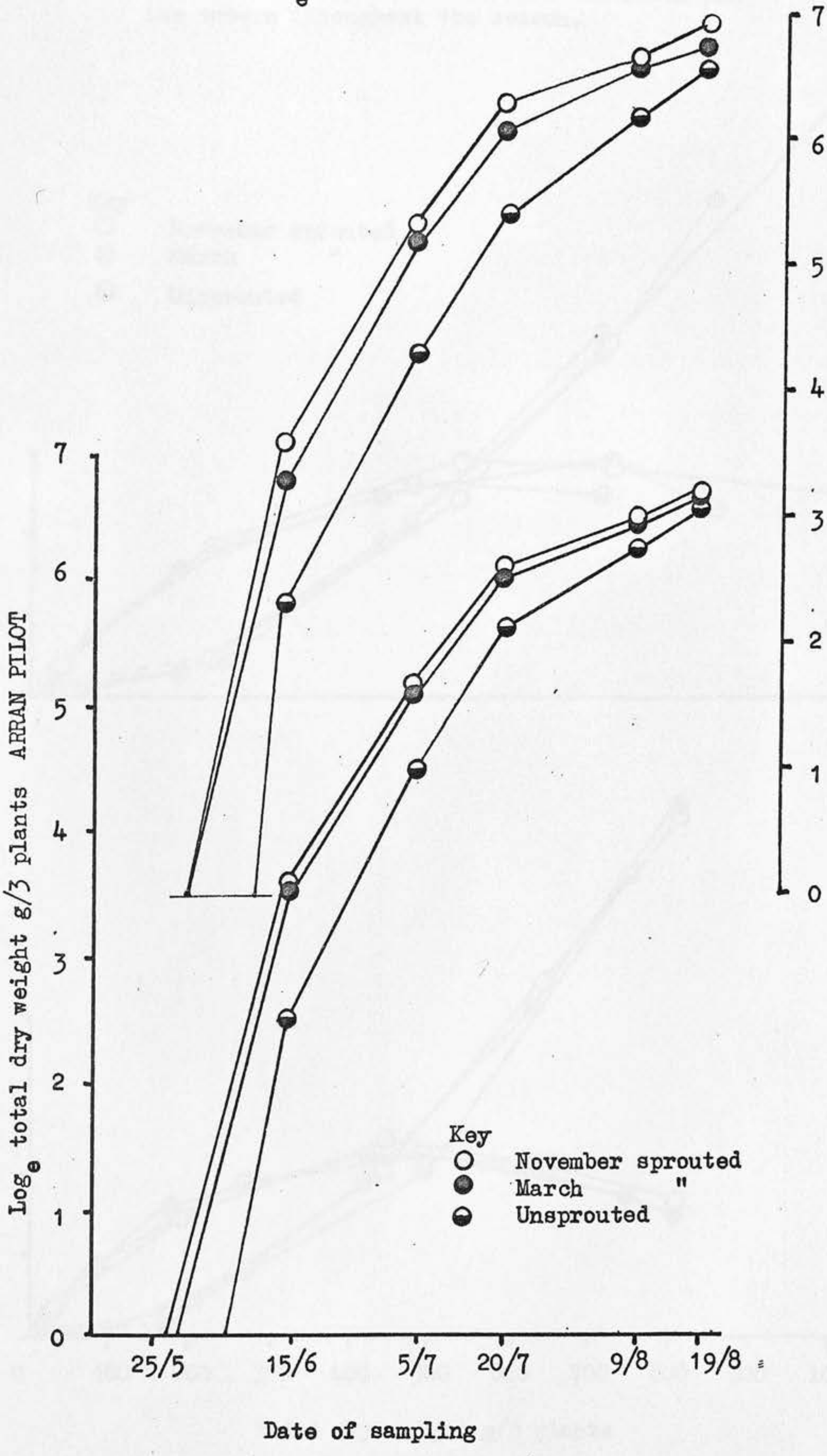
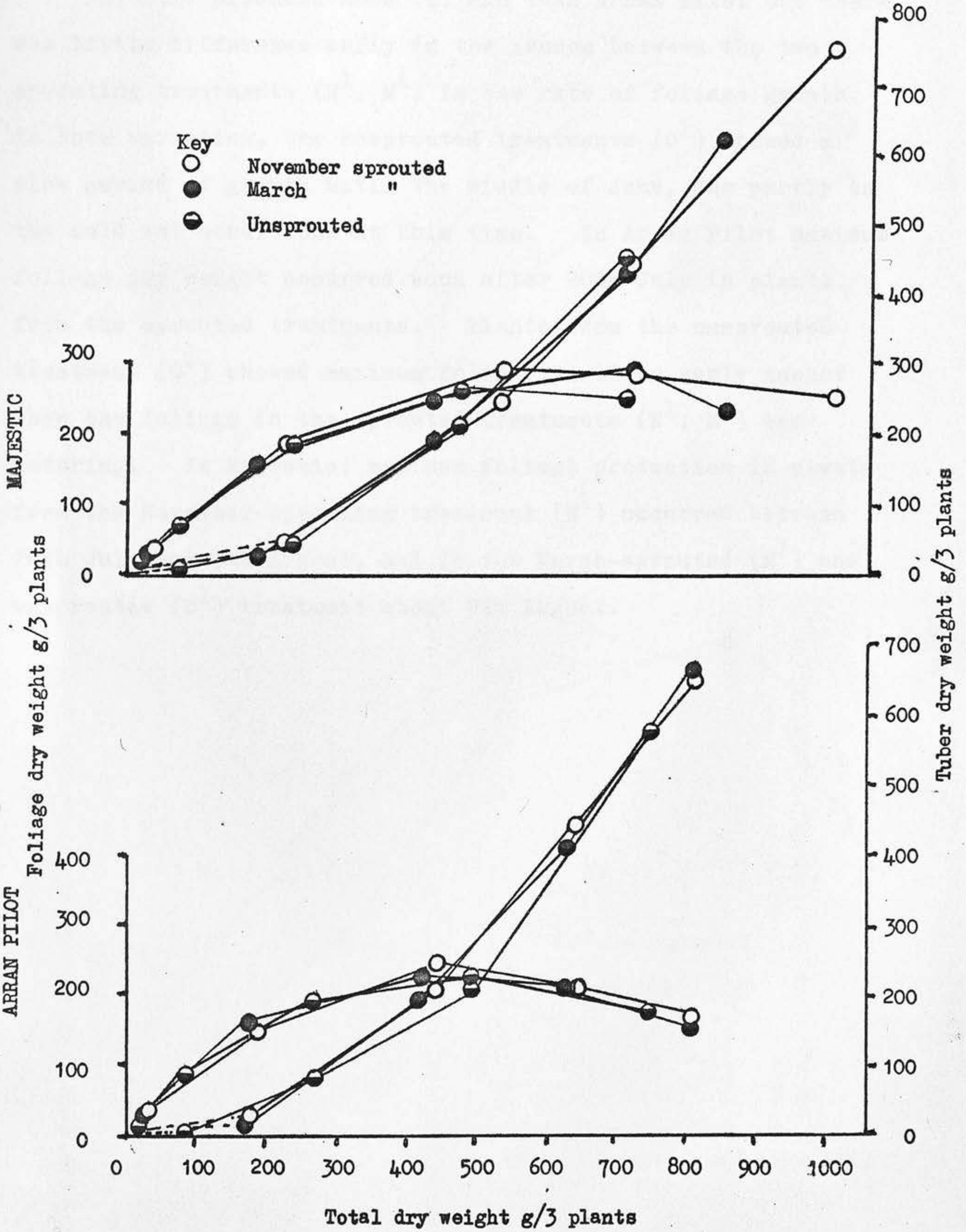


__Figure 10__ Effect of the current season's treatments on the partition of dry matter between the haulm and the tubers throughout the season.



3.3.5. <u>Haulm growth</u> (figure 11)

Majestic produced more foliage than Arran Pilot but there was little difference early in the season between the two sprouting treatments (N^1, M^1) in the rate of foliage growth. In both varieties, the unsprouted treatments (O^1) showed a slow period of growth until the middle of June, due partly to the cold wet conditions at this time. In Arran Pilot maximum foliage dry weight occurred soon after 20th July in plants from the sprouted treatments. Plants from the unsprouted treatment (O^1) showed maximum foliage yield in early August when the foliage in the sprouted treatments (N^1, M^1) was maturing. In Majestic, maximum foliage production in plants from the November-sprouting treatment (N^1) occurred between 20th July and 9th August, and in the <u>March</u>-sprouted (M^1) and unsprouted (O^1) treatment about 9th August.

Figure 11 Effect of the current season's treatments on the change in foliage dry weight with time.

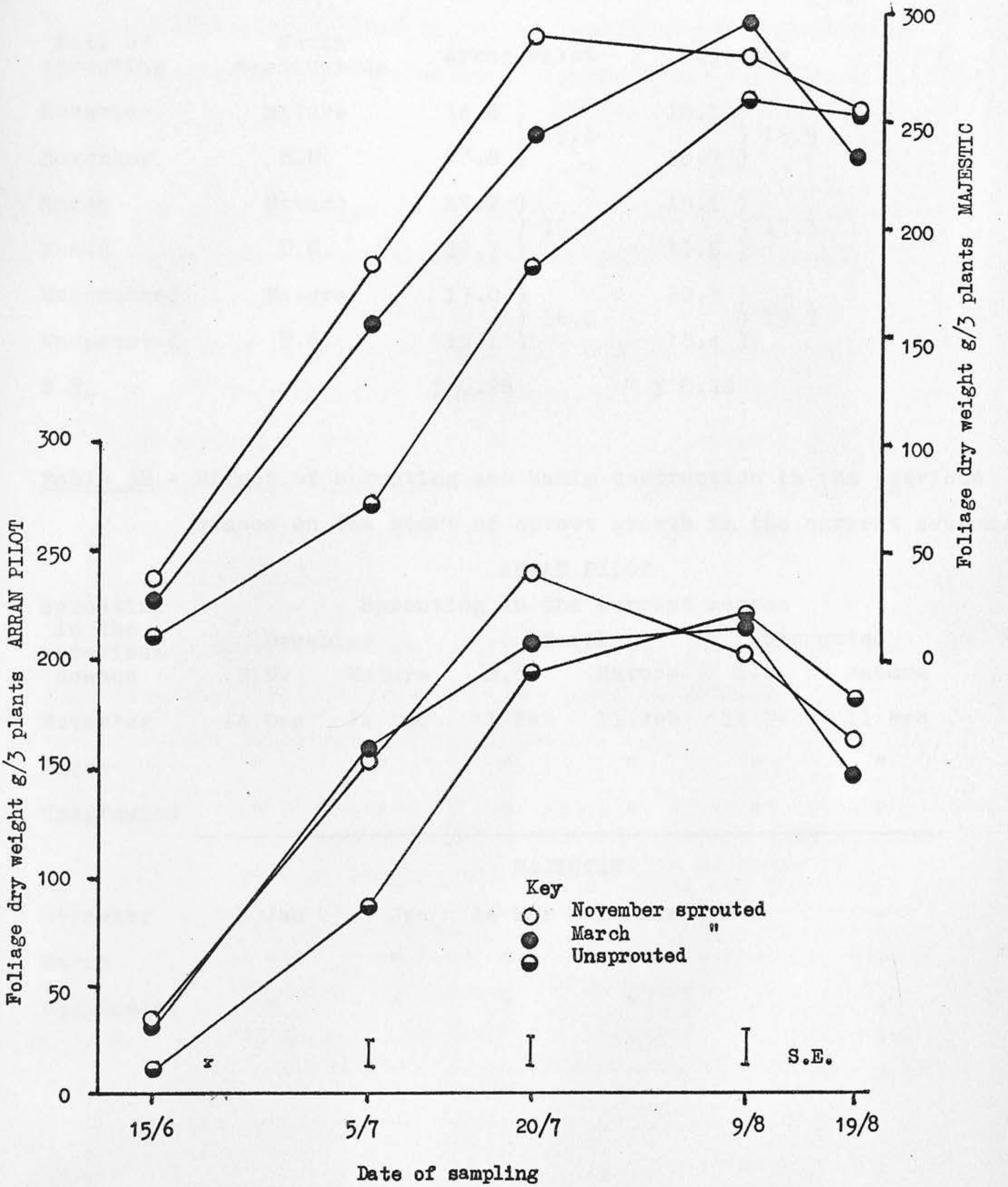


Table 31 - Effect of the previous season's treatments on dry matter percentage of tubers at harvest.

Date of sprouting	Haulm destruction	Arran Pilot		Majestic	
November	Mature	16.8	15.4	18.1	16.9
November	B.O.	13.8		15.7	
March	Mature	17.2	15.4	19.1	17.3
March	B.O.	13.7		15.6	
Unsprouted	Mature	17.0	16.0	20.3	19.3
Unsprouted	B.O.	15.1		18.4	
S.E.		± 0.28		± 0.28	

Table 32 - Effect of sprouting and haulm destruction in the previous season on the start of sprout growth in the current season.

Sprouting in the previous season	Sprouting in the current season					
	December		March		Unsprouted	
	B.O.	Mature	B.O.	Mature	B.O.	Mature
ARRAN PILOT						
November	14 Dec	14 Dec	11 Feb	11 Feb	11 Feb	11 Feb
March	"	"	"	"	"	"
Unsprouted	"	"	"	"	"	"
MAJESTIC						
November	3 Jan	3 Jan	14 Mar	14 Mar	-	-
March	"	"	"	"	-	-
Unsprouted	"	"	"	"	-	-

Experiment 2 - 1965-66

4. Materials and methods

F.S. - Scottish grade seed of both Arran Pilot and Majestic for the production of a mother crop was treated in the following way.

1964-65

N - Sprouted in November at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.

M - Sprouted in March at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.

O - Unsprouted; cold stored at 35^{o} - 45^{o}F till planting and white sprouts removed at planting (only necessary in Arran Pilot).

Tubers were planted in the field in 1965 in a randomised block design. Half of each treatment was burned off (B.O.) and half left to mature naturally (Mat.).

Table 30 - Dates of burning off and maturity of the mother crop.

	Date of burning off		Date of maturity of plots not burned off	
	Arran Pilot	Majestic	Arran Pilot	Majestic
Sprouted	30 July	7 August	20 August	30 August
Unsprouted	13 August	20 August	25 August	11 September

Seed tubers from the 6 treatment combinations of this mother crop were retained (unfortunately it was not possible to separate them by replicate) and sorted into two seed sizes (mean tuber weights 98 g and 48 g in Arran Pilot and 107 g and 64 g in Majestic) and given the following treatments in the current season.

1965-66

A - Sprouted in December at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.

B - Sprouted in March at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.

C - Unsprouted; cold stored at 35^{o} - 45^{o}F till planting and white sprouts removed at planting (only necessary in Arran Pilot).

All trays were equalised for the weight and the number of tubers. Five tubers of approximately average weight were marked and sprout development was recorded at 2-weekly intervals until planting time. Mainstem and lateral stem development after planting was followed on three of them. Sprouting and storage management was similar to Experiment 1, Section 1.2. Storage temperatures are shown in figure 2 of the Appendix. In the treatments B and C in Arran Pilot, sprouts had appeared on the tubers in store by February and these were removed from the (B) tubers before setting up for sprouting, and from the (C) tubers on 18th April. At planting time, the unsprouted tubers (C) were scored for the incidence of skin spot and the results are given in table 1 of the Appendix. Sample tuber weights and the movement of trays are given in the Appendix - tables 2 and 3 respectively. The percentage dry matter in the tubers from the various first season treatments was measured at harvest time (table 31).

The field experiment was of split-plot design with variety in main plots (seed size was confounded with blocks), the three current season's treatments in sub-plots and the six treatments (3 x 2 factorial) from the previous season in sub sub-plots. There were 3 replicates. The experiment was carried out on the University Farm following a barley crop on a clay-loam soil at 450'. Ten tons of F.Y.M. were applied in the autumn and ploughed in. One hundred units of N and P_2O_5 and 120 units of K_2O were broadcast in April before working. Planting took place on 27th April. The experiment was ridged up after planting and no further cultivations took place. Weeds were controlled by spraying with a mixture of linuron (3 lb. per acre A.I.) and paraquat (3 pints per acre) in 30 gallons of water on 18th May. Protective blight spraying was carried out on 1st, 13th July and 1st, 26th August. Plot size, layout and sampling procedure were the same as in the previous year's experiment (Section I.2) with the exception of tuber grading where the grades 0-25g, 25-50g, 50-100g, 100-150g, 150-200g, 200-300g and > 300g were employed. Coefficients of variation were about 20% of the ~~plot~~ sample mean for a series of attributes.

Final harvest was not carried out as a result of severe damage to the crop by flooding on August 13th, 14th and 15th.

The sampling occasions were: (1) 15/16 June, (2) 4/5 July, (3) 17/18 July, (4) 10/11 August, and (5) 21/22 August.

Field scores for emergence were carried out on 26th, 30th May and 3rd, 6th and 9th June.

5. Results

5.1. Sprout growth during the storage period, sprout development at planting time and stem growth

5.1.1. The start of sprout growth (table 32)

There was no evidence that haulm destruction or the date of sprouting in the previous season had any effect upon the time when the sprouts started to grow.

5.1.2. Sprout number (table 33, figures 12, 13, 14, 17)

There was no effect of the previous season's treatments on sprout number during growth or at planting time within either of the sprouted lots in the current season. Usually Arran Pilot produces more sprouts than Majestic but here Majestic produced a significantly greater number of sprouts than Arran Pilot by planting time, and this may have been due to the slightly larger size of seed used in Majestic than Arran Pilot (average of 85 g and 73 g respectively). March-sprouting in the current season (B) produced a greater number

Table 33 - Effect of a) sprouting in the previous season (N, M, O) and in the current season (A, B),
b) maturity (B.O. Mat.) and sprouting in the previous season (N, M, O), and
c) maturity (B.O. Mat.) and sprouting in the current season (A, B)
on sprout number per tuber at planting time.

a)

	ARRAN PILOT				MAJESTIC				
	N	M	O	Mean	N	M	O	Mean	Mean
A	6.56	6.61	7.06	6.74	9.11	9.17	8.61	8.96	7.85
B	10.22	10.61	9.89	10.24	12.39	12.67	12.17	12.41	11.32
Mean	8.39	8.61	8.47	8.49	10.75	10.92	10.39	10.69	

Standard errors

Marginal means:			Body of table:
1) within variety	(horizontal	±0.436	within variety ±0.467
	(vertical	±0.405	
2) between varieties	(horizontal	±0.364	
	(vertical	±0.246	

b)

	ARRAN PILOT				MAJESTIC				
	N	M	O	Mean	N	M	O	Mean	Mean
B.O.	8.78	8.44	9.00	8.74	11.28	11.94	11.22	11.48	10.11
Mat.	8.00	8.78	7.94	8.24	10.22	9.89	9.56	9.89	9.06
Mean	8.39	8.61	8.47	8.49	10.25	10.92	10.39	10.69	

Standard errors

Marginal means:			Body of table:
1) within variety	(horizontal	±0.436	within variety ±0.308
	(vertical	±0.356	
2) between varieties	(horizontal	±0.364	
	(vertical	±0.263	

c)

	ARRAN PILOT			MAJESTIC			
	A	B	Mean	A	B	Mean	Mean
B.O.	7.07	10.41	8.74	9.52	13.44	11.48	10.11
Mat.	6.41	10.07	8.24	8.41	11.37	9.89	9.06
Mean	6.74	10.24	8.49	8.96	12.41	10.69	

Standard errors

Marginal means:			Body of table:
1) within variety	(horizontal	±0.405	within variety ±0.376
	(vertical	±0.356	
2) between varieties	(horizontal	±0.263	
	(vertical	±0.296	

of sprouts per tuber than the December-sprouting treatment (A) in both varieties. The fall in sprout number with March-sprouting in Majestic during the latter part of the storage phase was due to the death of a number of small lateral buds.

5.1.3. Sprouts > 8 mm at planting time (table 34)

There was no effect of the previous season's treatments on sprout numbers > 8 mm at planting. Sprouting in the current season resulted, in both varieties, in fewer sprouts > 8 mm per tuber from the December-sprouting treatment (A) than from the March-sprouting treatment (B).

5.1.4. Sprout length (table 35, figures 15, 16, 17)

There was an effect of sprouting in the previous season on sprout length per tuber in both Arran Pilot and Majestic when sprouted in December of the current season (A). The two first year-sprouting treatments (N, M) showed a similar behaviour and gave a greater sprout length than the unsprouted treatment (O) from about the time maximum sprout numbers were formed until planting time. No effect of sprouting in the previous season could be demonstrated in the March-sprouted lots (B) in the current season. Haulm destruction had no effect on sprout length per tuber at planting time in Majestic, but in Arran Pilot with December-sprouting in the current season (A), burning off resulted in a reduction in total sprout length compared with treatments left to mature naturally. No effect of haulm destruction could be demonstrated in Arran

Table 34 - Effect of a) sprouting in the previous season (N, M, O) and in the current season (A, B),
b) maturity (B.O. Mat.) and sprouting in the previous season (N, M, O), and
c) maturity (B.O. Mat.) and sprouting in the current season (A, B)

on the number of sprouts > 8 mm. per tuber at planting time.

a)

	ARRAN PILOT N	M	O	Mean	MAJESTIC N	M	O	Mean	Mean
A	2.89	2.83	2.44	2.72	2.22	2.00	1.78	2.00	2.36
B	3.17	3.11	3.44	3.24	4.11	3.56	3.50	3.72	3.48
Mean	3.03	2.97	2.94	2.98	3.17	2.78	2.64	2.86	

Standard errors

Marginal means:
1) within variety (horizontal ±0.176 (vertical ±0.245
2) between varieties (horizontal ±0.225 (vertical ±0.245

Body of table: within variety ±0.247

b)

	ARRAN PILOT N	M	O	Mean	MAJESTIC N	M	O	Mean	Mean
B.O.	2.89	3.11	2.61	2.87	3.06	2.83	2.56	2.81	2.84
Mat.	3.17	2.83	3.28	3.09	3.28	2.72	2.72	2.91	3.00
Mean	3.03	2.97	2.94	2.98	3.17	2.78	2.64	2.86	

Standard errors

Marginal means:
1) within variety (horizontal ±0.176 (vertical ±0.144
2) between varieties (horizontal ±0.225 (vertical ±0.201

Body of table: within variety ±0.250

c)

	ARRAN PILOT A	B	Mean	MAJESTIC A	B	Mean	Mean
B.O.	2.56	3.19	2.87	2.04	3.59	2.81	2.84
Mat.	2.89	3.30	3.09	1.96	3.85	2.91	3.00
Mean	2.72	3.24	2.98	2.00	3.72	2.86	

Standard errors

Marginal means:
1) within variety (horizontal ±0.245 (vertical ±0.144
2) between varieties (horizontal ±0.245 (vertical ±0.201

Body of table: within variety ±0.201

Table 35 - Effect of a) sprouting in the previous season (N, M, O) and in the current season (A, B),
b) maturity (B.O. Mat.) and sprouting in the previous season (N, M, O), and
c) maturity (B.O. Mat.) and sprouting in the current season (A, B)
on sprout length per tuber (mm.) at planting time.

a)

	ARRAN PILOT				MAJESTIC				
	N	M	O	Mean	N	M	O	Mean	Mean
A	82.06	76.17	61.33	73.19	50.67	43.06	36.39	43.37	58.28
B	62.28	62.11	63.67	62.69	64.28	57.50	58.83	60.20	61.44
Mean	72.17	69.14	62.50	67.94	57.47	50.28	47.61	51.79	

Standard errors

Marginal means:

1) within variety (horizontal ±3.25 (vertical ±2.58

2) between varieties (horizontal ±5.46 (vertical ±5.11

Body of table: within variety ±6.31

b)

	ARRAN PILOT				MAJESTIC				
	N	M	O	Mean	N	M	O	Mean	Mean
B.O.	69.33	66.39	55.50	63.74	56.56	54.83	50.17	53.85	58.80
Mat.	75.00	71.89	69.50	72.13	58.39	45.72	45.06	49.72	60.93
Mean	72.17	69.14	62.50	67.94	57.47	50.28	47.61	51.79	

Standard errors

Marginal means:

1) within variety (horizontal ±3.25 (vertical ±2.65

2) between varieties (horizontal ±5.46 (vertical ±5.12

Body of table: within variety ±4.60

c)

	ARRAN PILOT			MAJESTIC			
	A	B	Mean	A	B	Mean	Mean
B.O.	65.96	61.52	63.74	45.22	62.48	53.85	58.80
Mat.	80.41	63.85	72.13	41.52	57.93	49.72	60.93
Mean	73.19	62.69	67.94	43.37	60.20	51.79	

Standard errors

Marginal means:

1) within variety (horizontal ±3.25 (vertical ±2.58

2) between varieties (horizontal ±5.46 (vertical ±5.11

Body of table: within variety ±5.13

Figure 12 Effect of haulm destruction compared with natural maturity in the previous season on the change in sprout number with time when the tubers were set up to sprout in December and March of the current season.

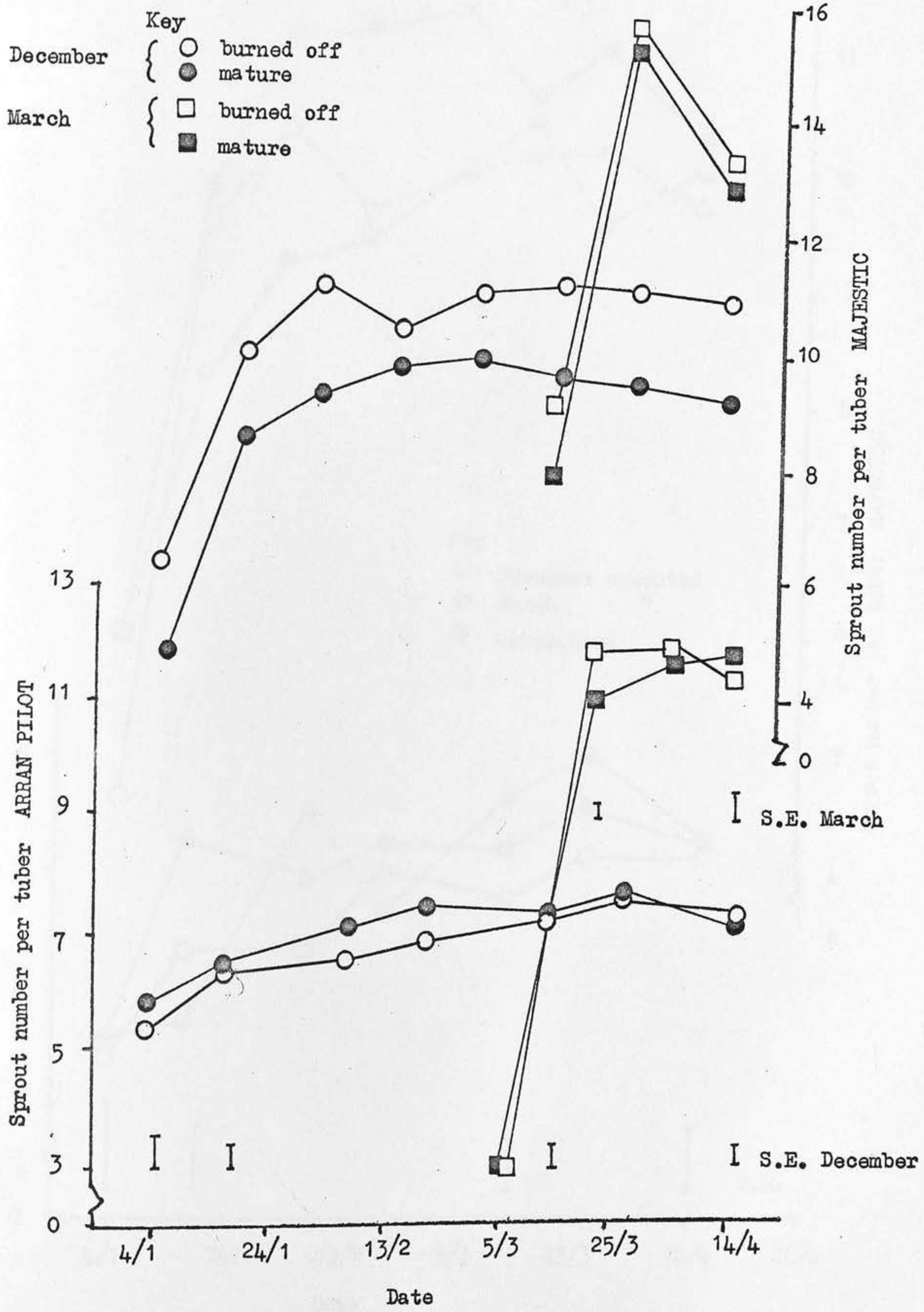


Figure 13 Effect of sprouting in the previous season on the change in sprout number with time when the tubers were set up to sprout in December of the current season.

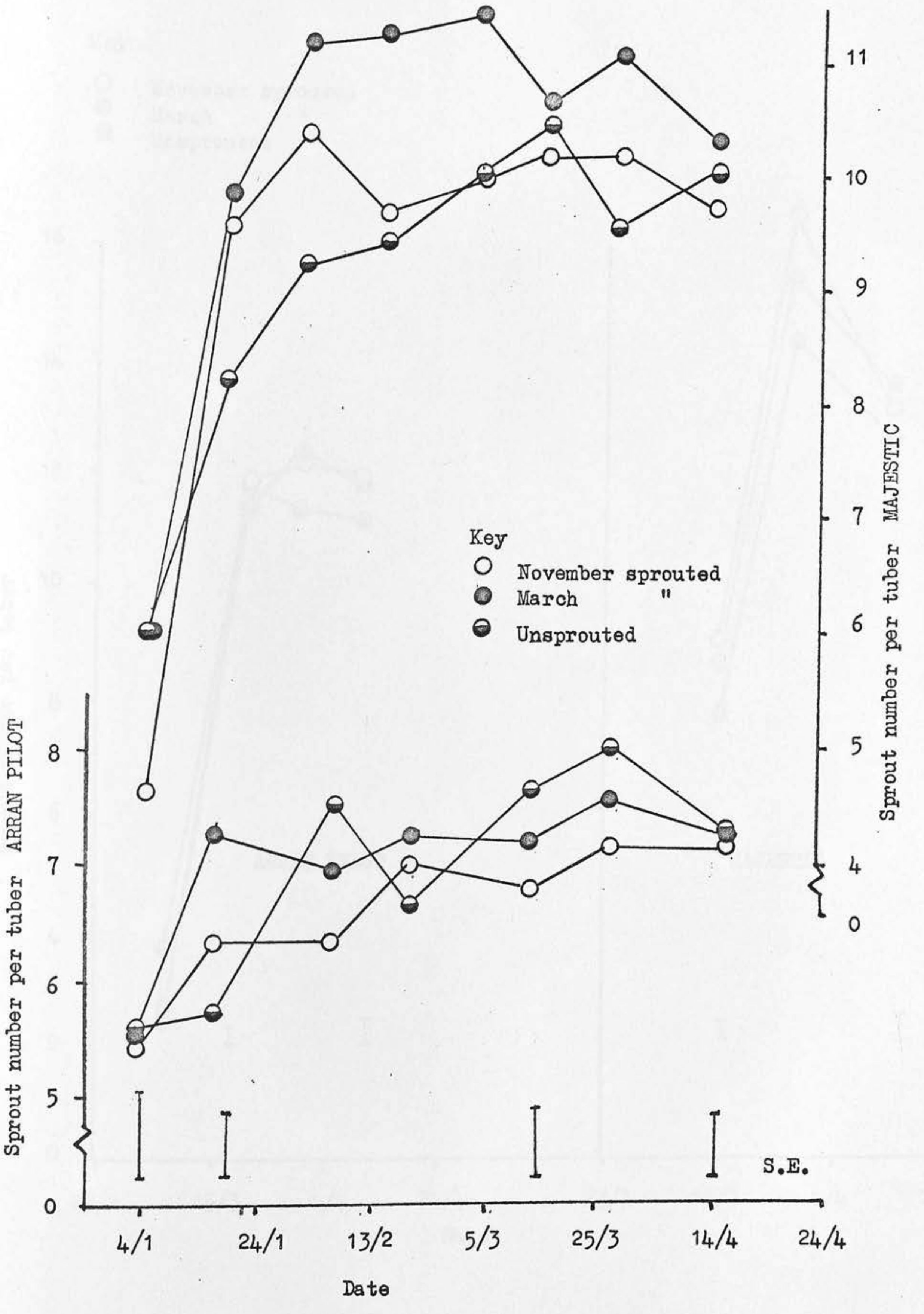


Figure 14 Effect of sprouting in the previous season on the change in sprout number with time when the tubers were set up to sprout in March of the current season.

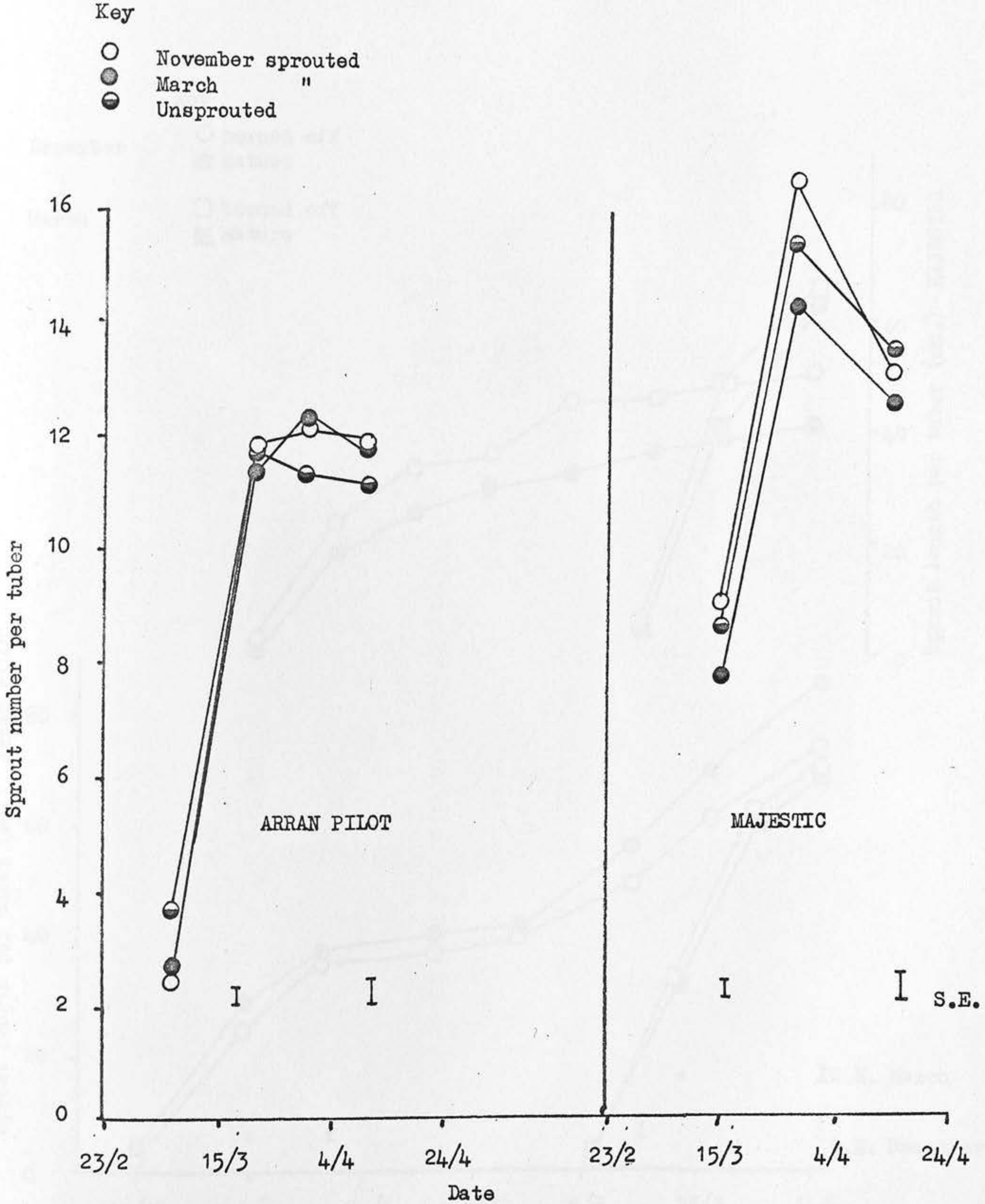


Figure 15 Effect of haulm destruction compared with natural maturity in the previous season on the change in sprout length (mm.) with time when the tubers were set up to sprout in December and March of the current season.

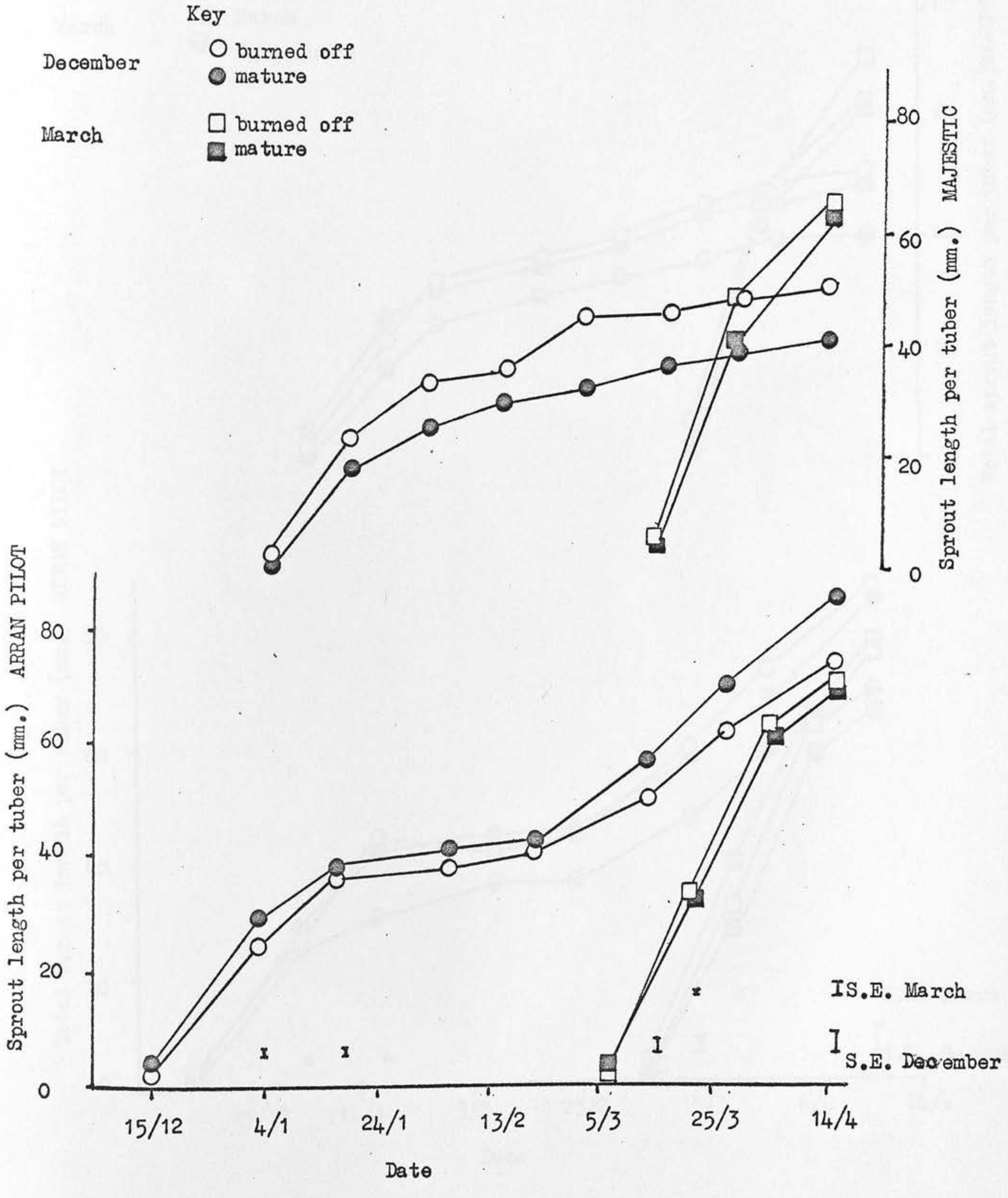


Figure 16 Effect of sprouting in the previous season on the change in sprout length with time when the tubers were set up to sprout in December and March of the current season.

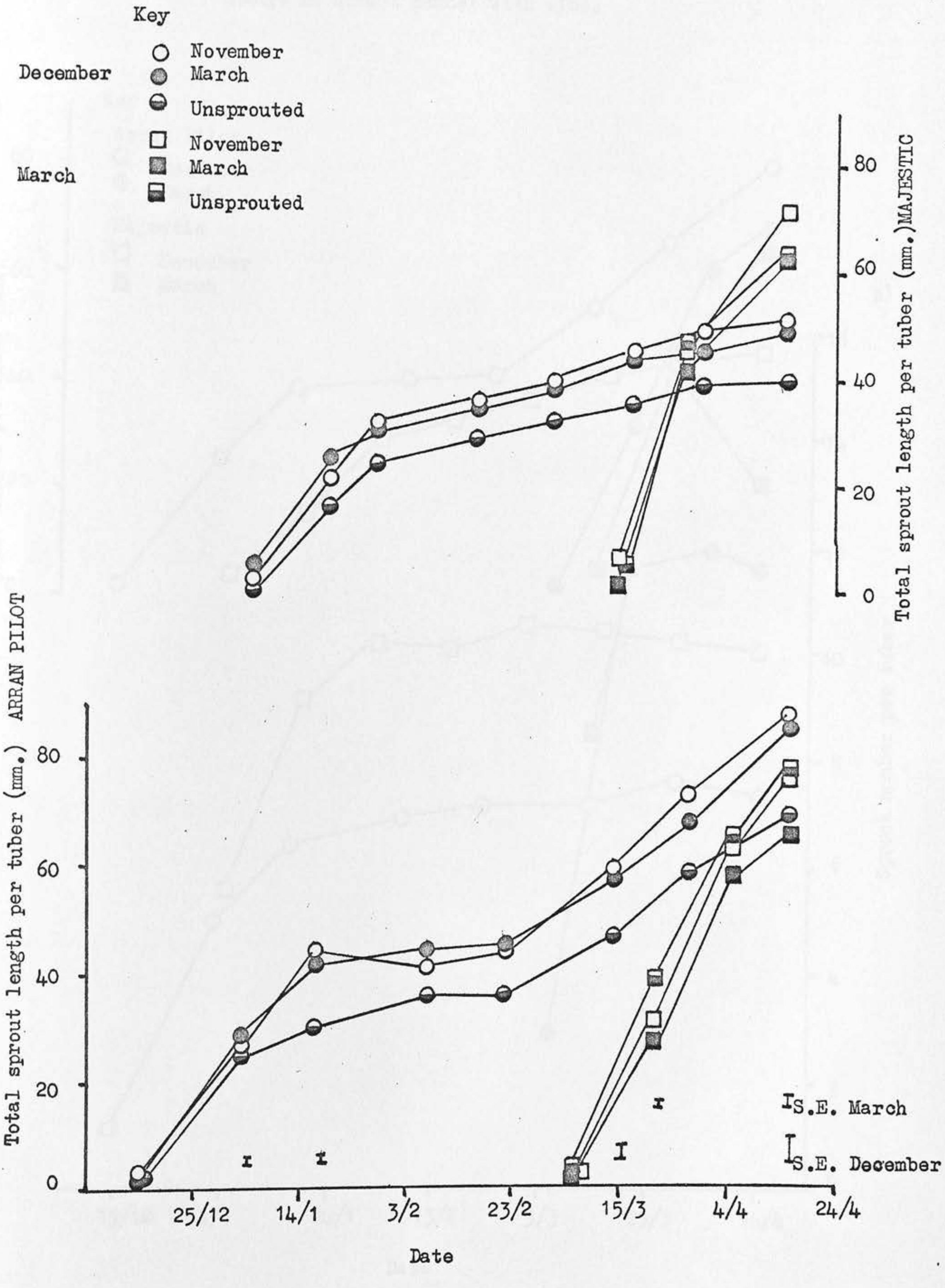
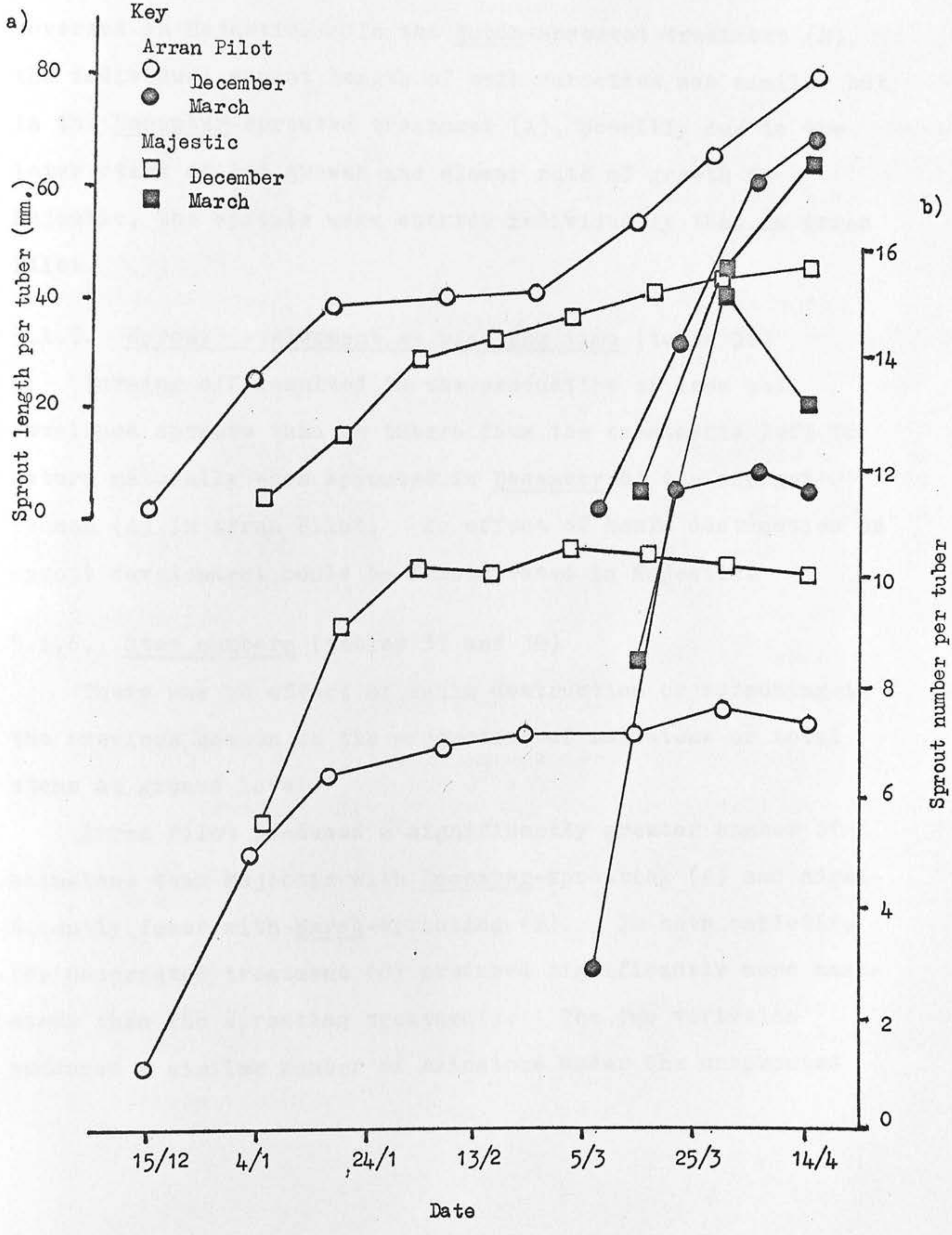


Figure 17 a) Effect of sprouting in the current season on the change in sprout length with time,

b) Effect of sprouting in the current season on the change in sprout number with time.



Pilot with the March-sprouted treatment (B).

A greater sprout length resulted from December-sprouting (A) than March-sprouting (B) in Arran Pilot but this was reversed in Majestic. In the March-sprouted treatment (B), the individual sprout length of both varieties was similar but in the December-sprouted treatment (A), possibly due to the later start of bud growth and slower rate of growth in Majestic, the sprouts were shorter individually than in Arran Pilot.

5.1.5. Sprout development at planting time (table 36)

Burning off resulted in the production of less well developed sprouts than on tubers from the treatments left to mature naturally when sprouted in December of the current season (A) in Arran Pilot. No effect of haulm destruction on sprout development could be demonstrated in Majestic.

5.1.6. Stem numbers (tables 37 and 38)

There was no effect of haulm destruction or sprouting in the previous season on the production of mainstems or total stems at ground level.

Arran Pilot produced a significantly greater number of mainstems than Majestic with December-sprouting (A) and significantly fewer with March-sprouting (B). In both varieties the unsprouted treatment (C) produced significantly more mainstems than the sprouting treatments. The two varieties produced a similar number of mainstems under the unsprouted

Table 36 - Effect of a) sprouting in the previous season (N, M, O) and in the current season (A, B),
b) maturity (B.O., Mat.) and sprouting in the previous season (N, M, O), and
c) maturity (B.O., Mat.) and sprouting in the current season (A, B)
on the number of lateral branches per tuber at planting time.

a)

	ARRAN PILOT N	M	O	Mean	MAJESTIC N	M	O	Mean	Mean
A	10.67	9.22	7.39	9.09	3.67	3.39	3.28	3.44	6.27
B	5.33	4.44	5.89	5.22	0.44	0.50	0.44	0.46	2.84
Mean	8.00	6.83	6.64	7.16	2.06	1.94	1.86	1.95	

Standard errors

Marginal means:			Body of table:	
1) within variety	(horizontal	±0.386	within variety	±0.381
	(vertical	±0.307		
2) between varieties	(horizontal	±0.678		
	(vertical	±0.638		

b)

	ARRAN PILOT N	M	O	Mean	MAJESTIC N	M	O	Mean	Mean
B.O.	7.06	6.44	6.28	6.59	2.17	2.06	1.39	1.87	4.23
Mat.	8.94	7.22	7.00	7.72	1.94	1.83	2.33	2.04	4.83
Mean	8.00	6.83	6.64	7.16	2.06	1.94	1.86	1.95	

Standard errors

Marginal means:			Body of table:	
1) within variety	(horizontal	±0.386	within variety	±0.546
	(vertical	±0.315		
2) between varieties	(horizontal	±0.678		
	(vertical	±0.640		

c)

	ARRAN PILOT A	B	Mean	MAJESTIC A	B	Mean	Mean
B.O.	8.33	4.85	6.59	3.37	0.37	1.87	4.23
Mat.	9.85	5.59	7.72	3.52	0.56	2.04	4.88
Mean	9.09	5.22	7.16	3.44	0.46	1.95	

Standard errors

Marginal means:			Body of table:	
1) within variety	(horizontal	±0.307	within variety	±0.311
	(vertical	±0.315		
2) between varieties	(horizontal	±0.678		
	(vertical	±0.640		

Table 37 - Effect of sprouting in the previous season (N, M, O), maturity (B.O., Mat.) and sprouting in the current season (A, B, C) on mainstem number per hill.

	N			M			O					
	B.O.	Mat.	Mean	B.O.	Mat.	Mean	B.O.	Mat.	Mean	Mean B.O.	Mean Mat.	Mean N + M + O
ARRAN PILOT												
A	2.33	2.19	2.27	2.52	2.44	2.48	2.27	2.17	2.22	2.38	2.27	2.32
B	2.69	2.84	2.77	2.75	2.19	2.47	2.77	2.75	2.77	2.74	2.59	2.67
C	3.58	3.22	3.41	4.06	3.44	3.75	3.08	3.64	3.37	3.57	3.44	3.51
Mean	2.86	2.75	2.81	3.11	2.69	2.90	2.72	2.85	2.78	2.83	2.77	
MAJESTIC												
A	1.86	2.14	2.00	2.03	1.81	1.92	1.56	1.61	1.58	1.81	1.85	1.83
B	3.06	3.25	3.15	3.11	3.08	3.10	3.25	2.61	2.93	3.14	2.98	3.06
C	3.27	3.50	3.39	3.50	3.19	3.35	3.08	3.17	3.12	3.29	3.29	3.28
Mean	2.73	2.97	2.85	2.88	2.69	2.78	2.63	2.47	2.55	2.75	2.71	

Standard errors

Marginal means:

Vertical comparisons for (A, B, C) within variety	± 0.075
Horizontal comparisons for (N, M, O) within variety	± 0.097
Horizontal comparisons for (B.O., Mat.) within variety	± 0.079
Vertical comparisons for (A, B, C) between variety	± 0.099
Horizontal comparisons for (N, M, O) between variety	± 0.112
Horizontal comparisons for (B.O., Mat.) between variety	± 0.096

Table 38 - Effect of sprouting in the previous season (N, M, O), maturity (B.O., Mat.) and sprouting in the current season (A, B, C) on the total number of stems at ground level per hill.

	N B.O.	N Mat.	Mean	M B.O.	M Mat.	Mean	O B.O.	O Mat.	Mean	Mean B.O.	Mean Mat.	Mean of N, M, O
ARRAN PILOT												
A	7.11	9.89	8.50	7.61	7.61	7.61	7.77	8.27	8.02	7.50	8.59	8.05
B	6.86	7.63	7.24	6.64	6.50	6.57	8.22	8.06	8.14	7.24	7.40	7.32
C	4.77	4.72	4.75	5.44	4.77	5.10	5.22	5.52	5.37	5.15	5.01	5.08
Mean	6.25	7.42	6.83	6.56	6.29	6.43	7.07	7.28	7.18	6.63	7.00	
MAJESTIC												
A	4.67	5.06	4.86	4.61	4.58	4.59	5.50	4.81	5.15	4.92	4.82	4.87
B	4.69	5.47	5.08	5.47	5.39	5.43	5.47	5.19	5.33	5.21	5.35	5.28
C	3.64	3.94	3.79	4.27	3.56	3.91	3.42	3.58	3.50	3.78	3.69	3.73
Mean	4.33	4.82	4.58	4.78	4.51	4.65	4.80	4.53	4.66	4.64	4.62	

Standard errors

Marginal means:

Vertical comparisons for (A, B, C) within variety	± 0.312
Horizontal comparisons for (N, M, O) within variety	± 0.207
Horizontal comparisons for (B.O., Mat.) within variety	± 0.169
Vertical comparisons for (A, B, C) between variety	± 0.362
Horizontal comparisons for (N, M, O) between variety	± 0.307
Horizontal comparisons for (B.O., Mat.) between variety	± 0.283

treatment (C). The two sprouted treatments (A, B), which produced a similar number of stems at ground level, gave a significantly greater number than the unsprouted treatment (C). The response was similar in both varieties.

5.1.7. Relationships between sprout numbers, sprout development and stem numbers

In both varieties March-sprouting (B) in the current season produced more sprouts per tuber and sprouts > 8 mm per tuber at planting time, and more mainstems than December-sprouting (A). Although the variation in sprout development and stem numbers was low among the previous season's treatments correlation coefficients between sprout and stem characters were made. All correlations were calculated as an analysis within seed size, variety, the current season's treatment and among the previous season's treatments on sprout and stem data obtained from marked tubers.

Mainstem numbers increased with an increase in sprout numbers at planting time ($r = 0.295$ N.S., d.f. 24 in Arran Pilot and $r = 0.543$ **, d.f. 24 in Majestic) but this was only significant in Majestic. The relationship between the number of large sprouts at planting time and mainstem number was positive and significant in both varieties ($r = 0.388$ * d.f. 24 in Arran Pilot and $r = 0.622$ ** d.f. 24 in Majestic). There was little lateral branch development of the sprouts in Majestic at planting time. In Arran Pilot there was a positive, significant relationship between an index of sprout development (see Section I, 3.1.7) and total stems at ground level ($r = 0.418$ * d.f. 24).

5.2. Field growth

5.2.1. General aspects of growth

The 1966 season was warm and dry in the early phases of growth. Emergence was even and there was very little blanking. There was, however, a high incidence of blackleg in Arran Pilot which was considerably aggravated by heavy rain in August causing flooding. Rapid tuber rotting followed and prevented the experiment from being harvested.

The effect of treatment on the dates of 50% emergence and apparent tuber initiation, days from planting to emergence and planting to apparent tuber initiation are shown in tables 39 and 40.

There was no effect of the previous season's treatments (N, M, O, B.O., Mat.) on the date of 50% emergence or apparent tuber initiation. In the current season the December-sprouting treatment (A) emerged about 2 days earlier than the March-sprouting treatment (B) in both varieties. The un-sprouted lots emerged between 7 and 9 days later than the sprouted lots. In Majestic the unsprouted lots initiated tubers 7-9 days later than those which had been sprouted but in Arran Pilot there was little difference among the treatments.

5.3. Growth analysis

There was no effect of the previous season's treatments (N, M, O, B.O., Mat.) on 1) development of tuber yield, 2) development of tuber number, 3) total dry matter production, or 4) foliage growth, and the data is presented in the Appendix, tables 12-16, averaged ~~of~~ over the current season's treatments. Only the data for the current season's sprouting treatments are presented here averaged over the previous season's treatments.

5.3.1. Development of tuber number (figure 18)

Maximum tuber numbers occurred 2 weeks after the start of tuber formation. Thereafter there was a large drop in tuber number until harvest. Most of the loss was in the 0-25g range (table 41) but there was little evidence of differential rates of tuber loss between treatments. In general treatments which initiated the greatest number of tubers produced the greatest number at the final lift: C > B > A in Majestic and B > A > C in Arran Pilot, but the differences were not significant (table 42).

5.3.2. Development of tuber yield (figure 19)

Bulking rates and times of apparent tuber initiation were calculated as in Experiment 1, Section I, 3.3.2 (excluding the data from lifts which showed the effects of flood damage) (table 43).

There was little difference in bulking rate between

Table 39 - Effect of sprouting in the current season (A, B, C), sprouting in the previous season (N, M, O) and maturity (B.O., Mat.) on the date of 50% emergence (E) and the date of apparent tuber initiation (I).

		ARRAN PILOT		MAJESTIC	
		E	I	E	I
	A	28 May	30 June	27 May	27 June
1965-66	B	30 May	1 July	29 May	25 June
	C	4 June	2 July	5 June	4 July
	N	1 June		31 May	
1964-65	M	1 June		31 May	
	O	1 June		31 May	
	B.O.	1 June		31 May	
	Mat.	1 June		1 June	

Table 40 - Effect of sprouting in the current season on the number of days from planting to emergence (P), planting to tuber initiation (T) and emergence to apparent tuber initiation (E).

	ARRAN PILOT			MAJESTIC		
	P	T	E	P	T	E
A	32	65	33	31	62	31
B	34	67	33	33	60	27
C	39	68	29	40	70	30

treatments with the exception of the unsprouted treatment in Arran Pilot, which showed a slower bulking rate. In this experiment the linear relationship provided a good fit to the increase in tuber fresh weight with time and accounted for more than 98% of the variance in tuber fresh weight. Tuber dry weight followed the same pattern as tuber fresh weight (table 44).

5.3.3. Rate of dry matter accumulation (figure 20)

Both varieties showed similar growth rates throughout the season, with a gradual decline in rate after the third sample lift. In both varieties December-, March-sprouted and unsprouted lots showed a similar behaviour in growth rate throughout the season.

5.3.4. Partition of dry matter (figure 21)

The partition of dry matter between the shoot and the tuber has been considered at similar stages of growth (Section I, 3.3.4). In both varieties the reciprocal effects of tuber and shoot growth can be clearly seen. In Arran Pilot more dry matter entered the tubers than in Majestic in the early stages of growth. There was a tendency for both varieties for more dry matter to enter the foliage early in the season in the unsprouted (O^1) than in the sprouted lots (N^1, M^1).

5.3.5. Haulm growth (figure 22)

Majestic produced a greater amount of foliage than Arran

Table 41 - Effect of sprouting in the current season and date of sampling on the number of tubers in grades (total of 18 plants).

Date of sampling		0-25	25-50	50-100	100-150	150-200	200-300	>300g
				ARRAN PILOT				
2	A	1194	33	6				
	B	1083	21	9	1			
	C	884	2					
3	A	711	176	122	19	6	2	0
	B	854	149	122	22	2	4	2
	C	801	198	73	2			
4	A	670	159	185	109	41	31	5
	B	647	133	179	88	48	29	8
	C	527	87	136	100	43	14	3
				MAJESTIC				
2	A	1206	47	4				
	B	1548	45					
	C	1217						
3	A	773	239	176	25	1		
	B	932	272	194	21			
	C	1162	147	32				
4	A	606	103	202	148	75	26	2
	B	623	137	221	132	62	20	0
	C	734	124	295	152	30	10	1

Table 42 - Effect of sprouting in the current season on tuber number, averaged over sample lifts 3, 4 and 5 (thousands per acre).

	December	March	Unsprouted	Mean
Arran Pilot	259.0	267.0	229.0	252.0
Majestic	258.0	281.0	291.0	277.0
				± 10.2
Mean	258.5	274.0	260.0 ± 13.9	

S.E. for horizontal comparisons ± 16.8

S.E. for body of table ± 16.5

Table 43 - Effect of sprouting in the current season on bulking rate g/pl/day (linear regression of fresh weight on time).

	Bulking rate g/pl/day	S.E.b	% variance removed	r	Equation Y = a + bX	Time of apparent tuber initiation
ARRAN PILOT						
A	25.4	±2.37	99	+0.99	Y = 25.4X - 1632	30 June
B	24.3	±4.01	99	+0.99	Y = 24.3X - 1571	1 July
C	20.3	±1.34	99	+0.99	Y = 20.3X - 1366	2 July
MAJESTIC						
A	24.5	±2.75	99	+0.99	Y = 24.5X - 1541	27 June
B	22.6	±8.1	99	+0.99	Y = 22.6X - 1352	25 June
C	24.9	±5.1	99	+0.99	Y = 24.9X - 1708	4 July

Table 44 - Effect of sprouting in the current season and date of sampling on the change in tuber dry matter (g/3 plants).

	Lift 2	Lift 3	Lift 4	Lift 5
		ARRAN PILOT		
December sprouted	50.1	246.1	608.6	517.9
March sprouted	37.9	234.7	579.6	516.6
Unsprouted	13.3	145.7	433.3	476.7
S.E.	± 4.5	± 8.58	± 35.85	± 35.57
		MAJESTIC		
December sprouted	60.8	254.6	626.9	815.2
March sprouted	72.2	296.9	606.4	694.9
Unsprouted	14.2	147.7	521.6	570.8
S.E.	± 4.5	± 8.58	± 35.85	± 35.57

Table 45 - Effect of sprouting in the current season on the incidence of 'coiled-sprout' expressed as a percentage of the total number of mainstems.

	December	March	Unsprouted	Mean
Arran Pilot	37.2	33.7	0.9	35.9
Majestic	30.0	17.7	0.3	24.0
Mean	33.6	25.7	0.6	29.9

Figure 18 Effect of the current season's treatments on the change in tuber number with time.

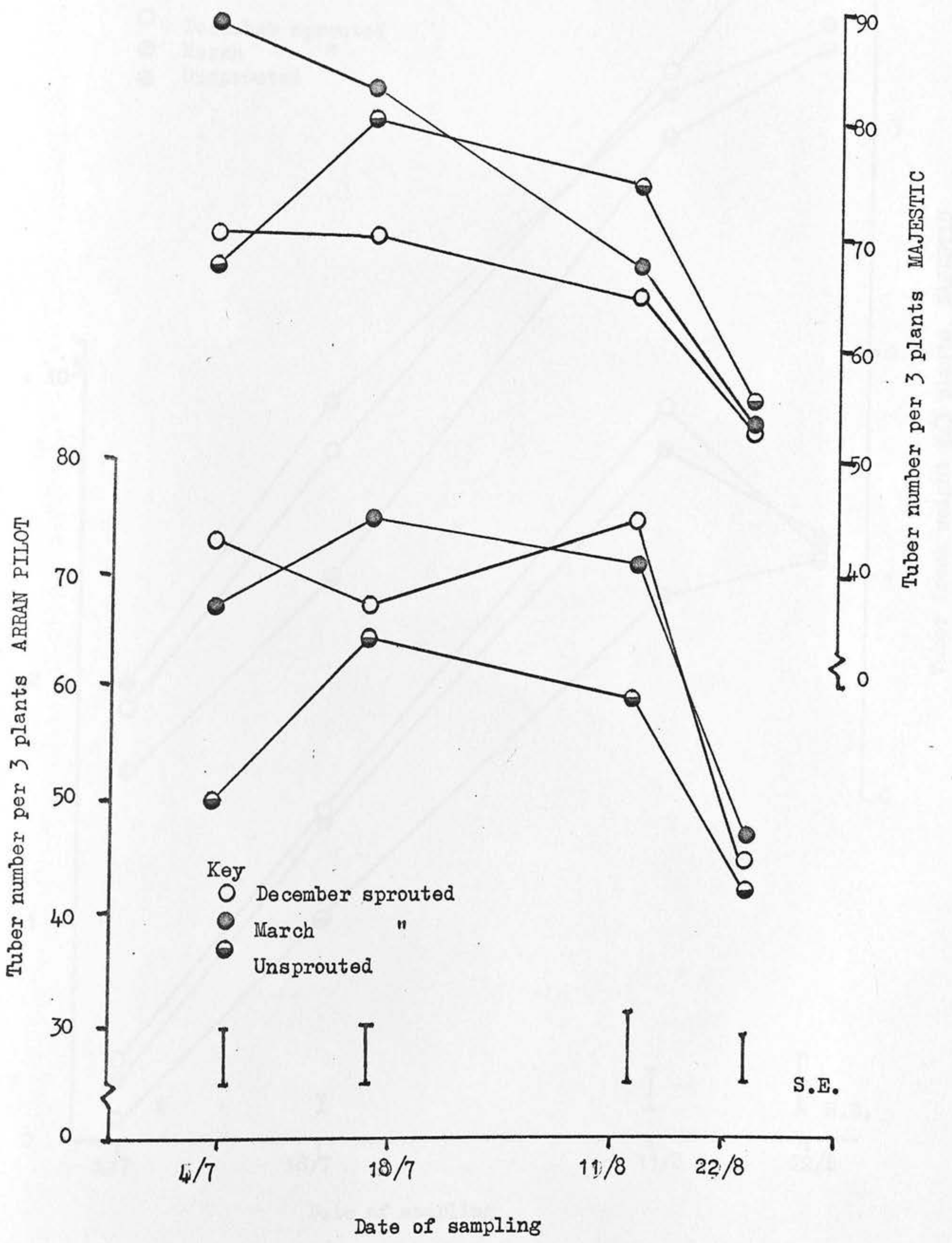


Figure 19 Effect of the current season's treatments on the change in tuber fresh weight with time.

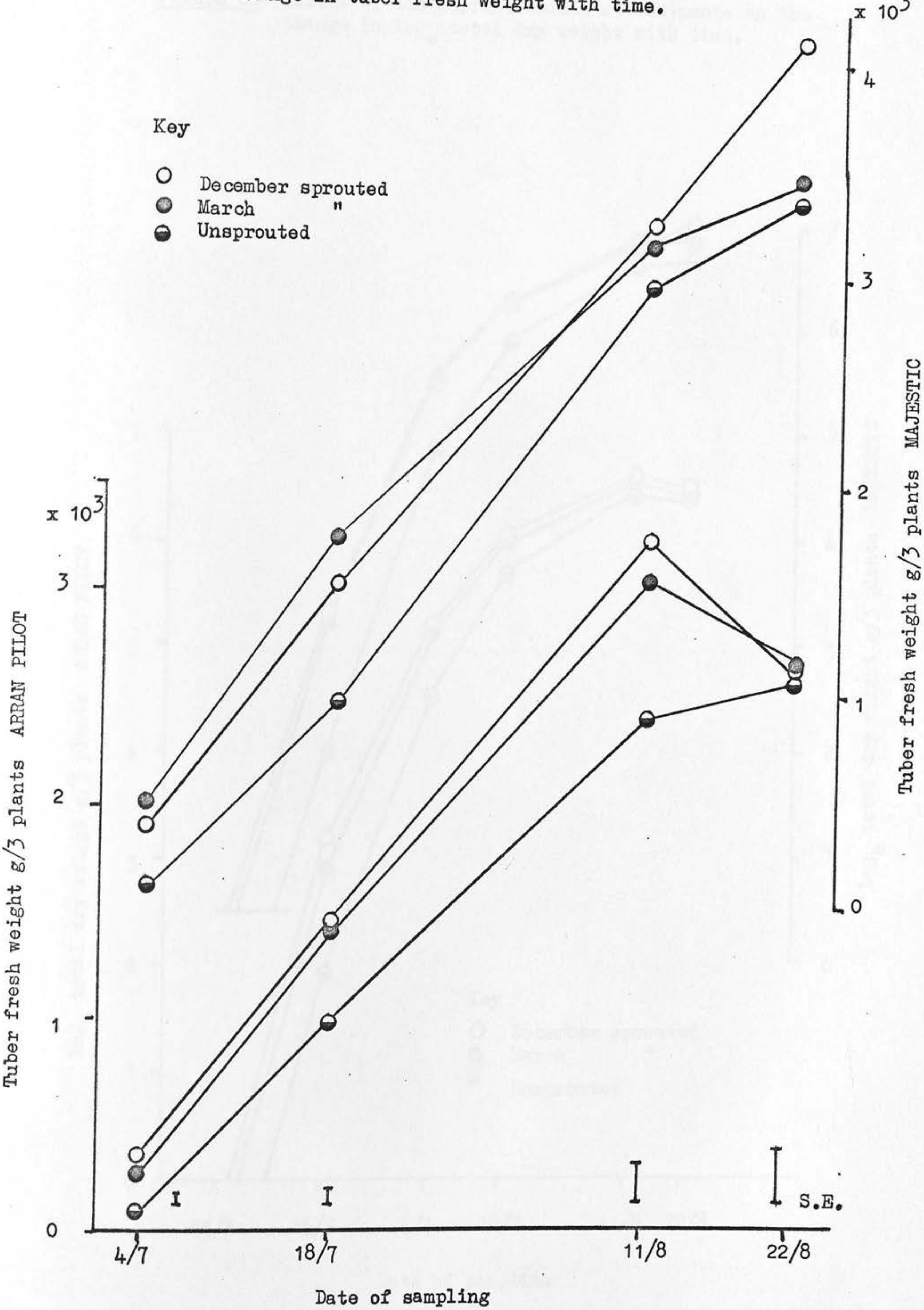


Figure 20 Effect of the current season's treatments on the change in $\log_e$ total dry weight with time.

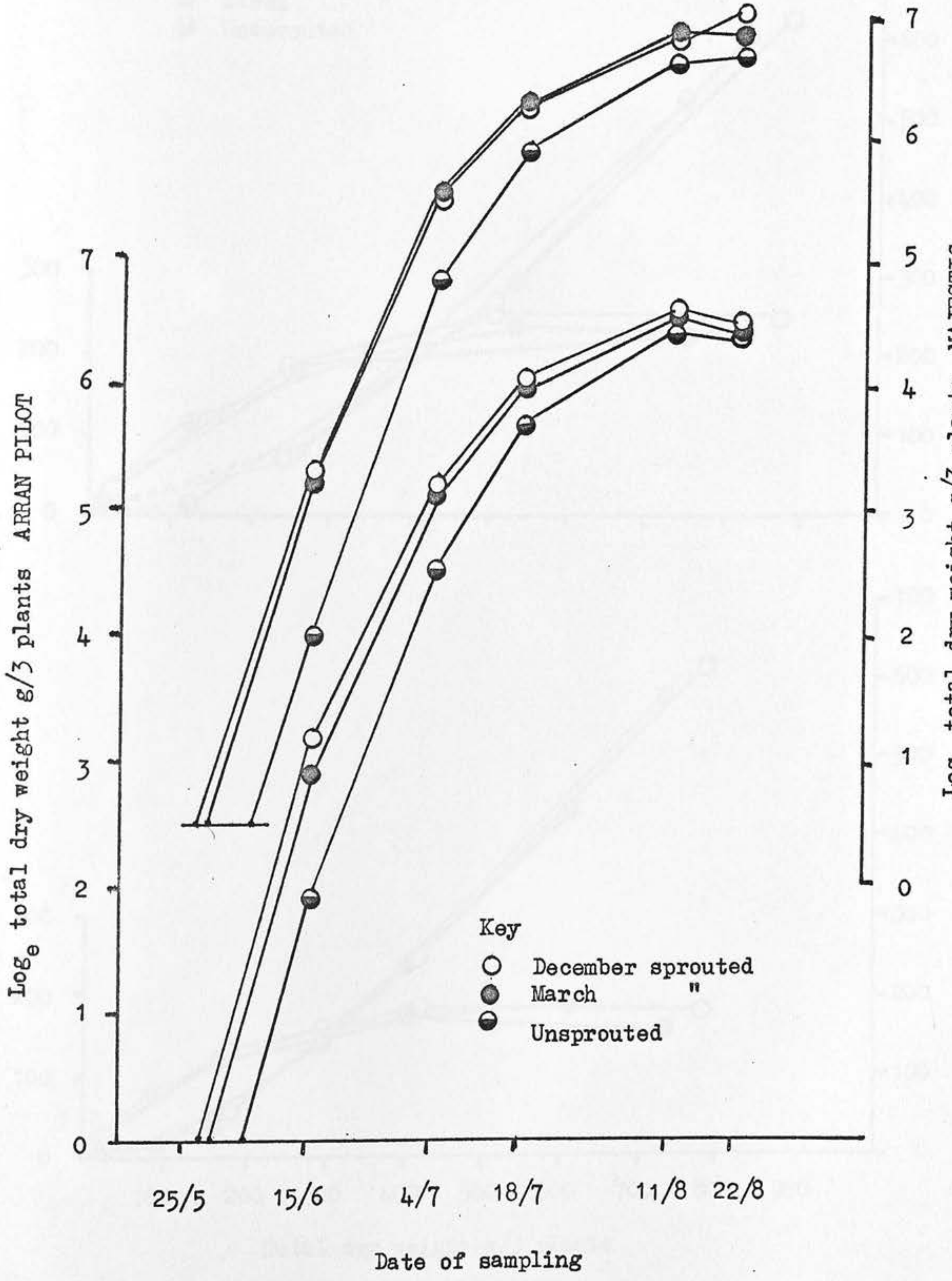


Figure 21 Effect of the current season's treatments on the partition of dry matter between the haulm and the tubers up to sample lift 4.

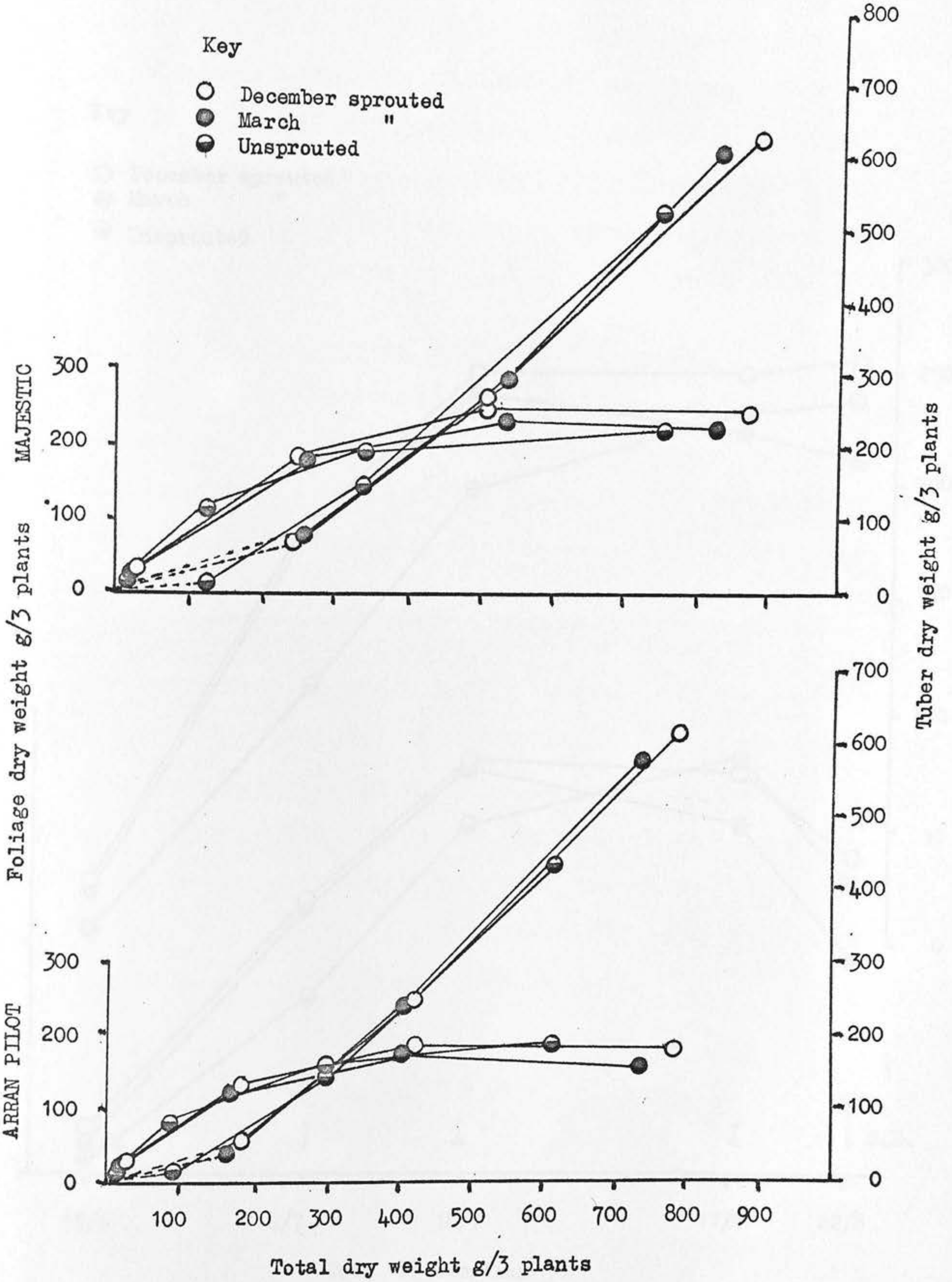
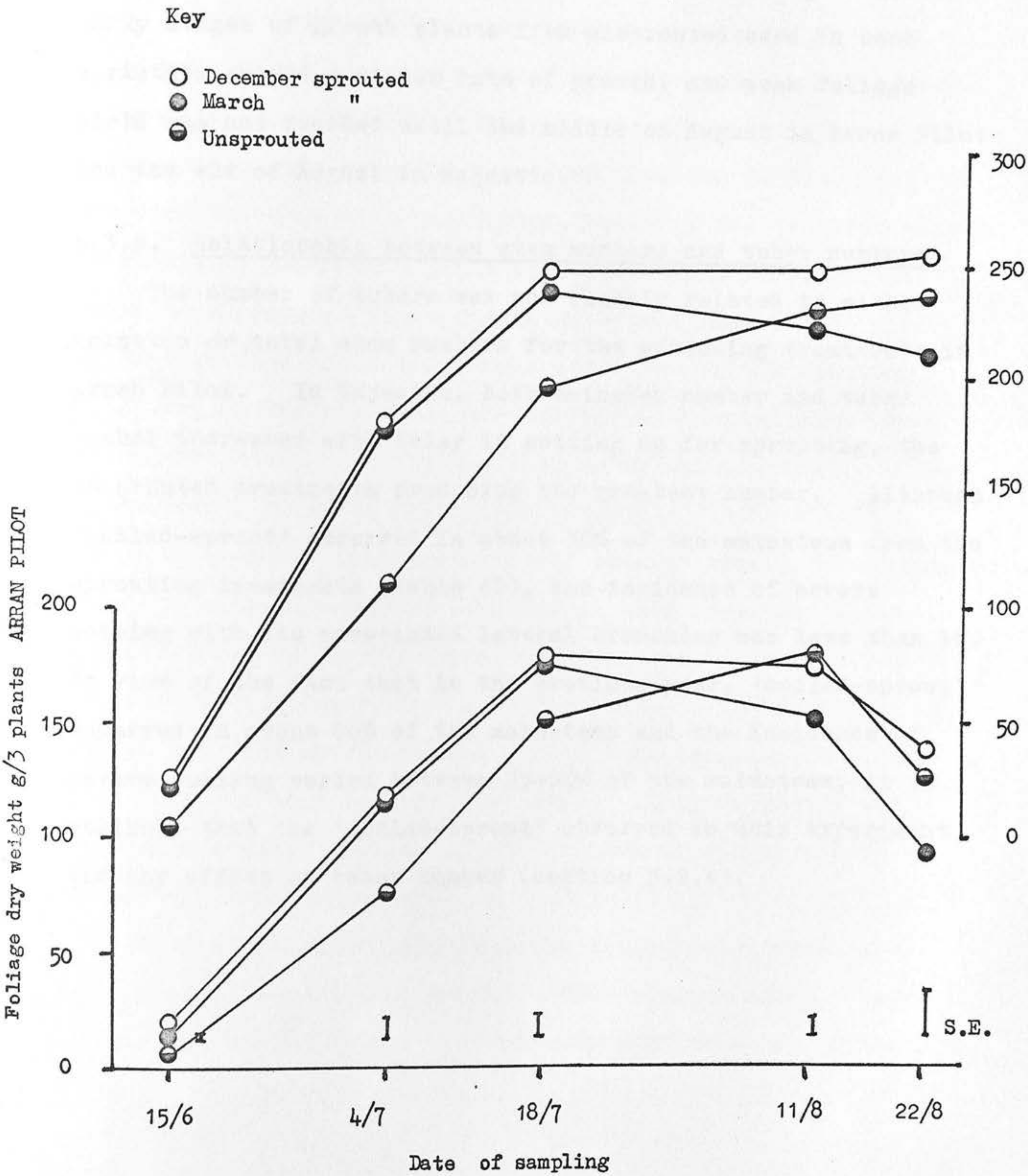


Figure 22 Effect of the current season's treatments on the change in foliage dry weight with time.



Pilot at all sampling dates. In both varieties plants from sprouted seed behaved similarly, reaching maximum foliage yield during the latter part of July. March-sprouting tended to cause earlier senescence than December-sprouting. In the early stages of growth plants from unsprouted seed in both varieties showed a slower rate of growth, and peak foliage yield was not reached until the middle of August in Arran Pilot and the end of August in Majestic.

5.3.6. Relationship between stem numbers and tuber numbers

The number of tubers was not clearly related to either mainstem or total stem numbers for the sprouting treatments in Arran Pilot. In Majestic, both mainstem number and tuber number increased with delay in setting up for sprouting, the unsprouted treatments producing the greatest number. Although 'coiled-sprout' occurred in about 30% of the mainstems from the sprouting treatments (table 45), the incidence of severe coiling with its associated lateral branching was less than 1%. In view of the fact that in the previous year, 'coiled-sprout' occurred in about 80% of the mainstems and the incidence of severe coiling varied between 25-50% of the mainstems, it is unlikely that the 'coiled-sprout' observed in this experiment had any effect on tuber number (section 3.2.4).

6. <u>Discussion of the results from Experiment 1 1964-65 and Experiment 2 1965-66</u>

Earlier sprouting in the previous season in Experiment 1 resulted in earlier senescence of the crop and earlier sprouting in both varieties when set up for sprouting in November of the following season, but this could not be demonstrated in Experiment 2. These results for Experiment 1 are in agreement with those of Madec and Perennec (1955). Sprouted compared with unsprouted tubers in the previous season resulted, in Experiment 2 for both varieties, and in Arran Pilot in Experiment 1, in a greater sprout length per tuber. In Experiment 2, this effect was maintained until planting time, but in Experiment 1, the effect on sprout length could not be detected after about six weeks of sprout growth. In Experiment 1 in Arran Pilot there was little effect of the previous season's treatments on the rate of sprout growth and thus the effect on sprout length must have been due to the advantage gained by an earlier start in sprout growth, but in Experiment 2 it appeared that early in the sprouting phase, the tubers from the sprouted crop showed a faster rate of growth than tubers from the unsprouted crop. Krijthe (1962) has noticed a similar phenomenon in the rate of sprout growth in mature and immature tubers.

None of these effects could be demonstrated when tubers were set up to sprout in March in either experiment. There was no difference in the time at which sprouting commenced between burned off and mature tubers which in this case were harvested at the same date. These results are in agreement with those of Emilsson (1949) and Burton (1963). Haulm destruction in Arran Pilot, but not in Majestic, resulted in a smaller sprout length per tuber at planting time when seed from these treatments were sprouted in December, and also fewer lateral branches per tuber at planting time for both dates of sprouting. In Arran Pilot, burning off resulted in a lower percentage tuber dry matter, and also a decrease in the lateral branch development of the sprouts. In Majestic, although burning off resulted in a reduction in the dry matter content of the tubers, it did not affect lateral branch development. Lateral branch growth is promoted by an increased supply of inorganic nutrients, particularly nitrogen (Gregory and Veale, 1957; Watson, 1963). Although no analyses of tuber tissue were made in these experiments, Carpenter (1957) and Will (1966) have shown that considerable quantities of inorganic nutrients are translocated from the haulm to the tuber during the later stages of growth and so burning off the foliage before maturity may reduce the quantity of inorganic nutrients in the tuber. However, Thow (1968) could not demonstrate an effect of tuber N-content on the number of lateral nodes in sprouted Kerr's Pink tubers. The effect of the previous season's treatments on the start of sprout growth and the length of the sprout, which were small and transitory, are in agreement with the results of Koltermann

(1927), Rosa (1928), Emilsson (1949) and Wright and Peacock (1934). There was no effect of date of sprouting in the previous season or haulm destruction on sprout number, stem number, foliage or tuber growth, tuber yield or number. In this respect the results are in agreement with those of Goodwin (1964).

The effects of the sprouting treatments during the current season on sprout number and the degree of sprout development at planting time, stem numbers, field performance and tuber numbers and yield were, however, large. In both years, delay in setting up for sprouting in the current season resulted in a greater number of sprouts per tuber and sprouts > 8 mm per tuber and mainstems in the field, unsprouted tubers producing the greatest number of mainstems. The number of mainstems produced in Arran Pilot was similar in both years, though, due possibly to the slightly later date of setting up for sprouting in Experiment 2, there was not such a marked response to late sprouting over early sprouting. In Majestic, in Experiment 2 compared with Experiment 1, sprouting in March resulted in a larger response in mainstem number over December sprouting but there was little further increase from unsprouted tubers. It is unlikely that the degree of skin spot infection (Appendix, table 1) affected the response to sprouting. The pattern of total stem production in the two years was similar in both varieties, both early- and late-sprouted tubers producing a greater total number of stems at ground level than unsprouted tubers.

In both years maximum tuber numbers were developed over a period of 2 weeks from the beginning of tuber formation, and, thereafter, there was a decline to harvest. Similar results have been reported by Werner (1940), Krijthe (1955) and Bremner and Taha (1966). There was little evidence of differential rates of tuber survival between treatments and this is in contrast with the results of Radley (1963) and Burrage (1965), though in Experiment 2 there was a greater loss of tubers than in Experiment 1. In general those treatments that initiated the greatest number of tubers produced the greatest number of tubers at harvest.

In Experiment 1, in Arran Pilot, March-sprouting produced a significantly greater number of tubers than unsprouted or November-sprouted tubers. There were no significant treatment effects on tuber number in Majestic. The results in Experiment 2 for tuber number need to be treated with caution, since a final harvest could not be taken due to rotting of the tubers caused by flooding and an estimate of tuber number was made from three plants averaged over lifts 3, 4 and 5. They indicate that the March-sprouted and unsprouted treatments produced more tubers than December-sprouted treatments. Seed yield followed total tuber number closely with the exception of unsprouted Majestic in Experiment 1 where a low bulking rate, coupled with a reduction in the bulking period due to blight infection in the foliage, resulted in a greater proportion of the yield falling in the seed size range. Previous results (J.C. Holmes, unpublished; Introduction, table 1) for Arran Pilot and Majestic suggest there is little to be gained in tuber number by using sprouted seed over unsprouted seed in Majestic but on average in Arran Pilot, late sprouting produced more tubers and a greater seed yield than unsprouted or early-sprouted seed. Similarly, Eckersall and Bremner (1964) found little effect of sprouting on seed yield in King Edward or Majestic.

There was little relationship in either year between main-stem number and tuber number or the total number of stems at ground level and tuber number. If the sprouted treatments alone are considered, no relationship was found between tuber number and the total number of stems in either variety, but tuber number increased with an increase in mainstem number, with the exception of Majestic in Experiment 1. In this case the incidence of 'coiled-sprout' in promoting lateral branching resulted in an increase in tuber number, emphasising the importance of lateral branches in tuber formation (Das Gupta, 1962).

Previous sprouting experiments where all treatments were allowed to mature naturally) (J.C. Holmes, unpublished; table 1) have suggested that there is little to be gained in total yield in Arran Pilot or Majestic by using sprouted over un-sprouted seed, though Shotton (Terrington E.H.F., 1960) has obtained increases of $1\frac{1}{2}$ - $2\frac{1}{2}$ tons per acre with Majestic and

King Edward in E. Anglia; but in other years (Terrington E.H.F., 1959, 1961, 1962) there was little advantage in yield to be gained from sprouting. The large yield advantage of sprouted over unsprouted seed in Experiment 1 (17% in Arran Pilot and 15% in Majestic) can be related in Arran Pilot to a higher rate of bulking while in Majestic, the low rate of bulking in unsprouted tubers coupled with blight attacks in August, which restricted foliage growth, led to a lower yield. In this experiment final dry matter yields were not measured but dry matter yields were measured in a similar experiment (F.S. seed-multiplication experiment for Experiment 2) situated in the same field (table 31). If the figures for dry matter percentage in this experiment are accepted then the yield advantage for sprouted tubers on a fresh weight basis is nearly halved when considered on a dry weight basis. Radley (1963) has noted a slight increase in Net Assimilation Rate (N.A.R.) towards the end of the bulking phase. This may result in an increased movement of dry matter to the tubers. In this experiment, although N.A.R. was not measured there was a slight increase in the Relative Growth Rate (R.G.R.) in the unsprouted treatments relative to the sprouted treatments between 4th and 5th sample lifts.

Sprouted tubers in both varieties emerged and initiated tubers earlier than unsprouted tubers but in Experiment 2 emergence in the unsprouted tubers occurred earlier in the season relative to the sprouting treatments compared with

Experiment 1. This could be due to the more favourable climatic conditions (table 4 of the Appendix) during early growth in 1966.

Borah and Milthorpe (1959) and Goodwin (1964) could find no relationship between bulking rates and leaf area index (L.A.I.). Although, in both years of the present work, average bulking rates were similar within variety for large differences in the amount of foliage, there was an indication that the size of the foliage at the time of tuber initiation had an effect on the bulking rate, for in Experiments 1 and 2 for Arran Pilot and Experiment 1 for Majestic, the unsprouted treatment, which showed early tuber initiation relative to foliage development compared with the sprouting treatments, gave a low bulking rate. The data of Bremner and Radley (1966), which showed that bulking rate increased with an increase in L.A.I. up to 3 but not with a further increase in L.A.I., lends support to this.

The view has been held that, since tuber bulking remains constant over the bulking period, current weather conditions have little effect upon the rate of tuber growth (Borah and Milthorpe, 1959; Bremner and Radley, 1966; Goodwin, 1964), except where drought occurs (Radley <u>et al</u>., 1961). In Experiment 1 (Section I, 3.3.2), although in the sprouted treatments tuber growth showed a good approximation to constant bulking over the growth period, the unsprouted treatments did not. Early in the bulking phase of the latter, slow bulking rates were associated with slow rates of foliage growth. This was possibly a result of the cold, wet conditions at the time of tuber initiation in the unsprouted treatments, for Burt (1961, 1964) has shown that plants exposed for short periods to low temperature (7°C) in the early stages of growth initiate tubers earlier relative to foliage development than plants exposed for short periods to high temperatures (15°C). This was associated with a reduction in the Relative Growth Rate (R.G.R.) and a reduction in leaf growth. Later in the season in this experiment, foliage growth was much more rapid and there was an increase in R.G.R. which was accompanied by a more rapid rate of bulking, giving, for tuber growth, a curvilinear and not a linear relationship with time. Tuber dry matter production followed the same pattern, indicating that differences in the rate of supply of carbohydrate from the foliage were responsible. From figure 8, Section I, 3.3.2, it is clear that a similar but smaller effect on tuber bulking occurred for both the sprouting treatments, suggesting that the larger size of the foliage from the sprouting treatments had a buffering effect upon differences in the supply of dry matter to the tubers. The data, however, are not comprehensive enough to allow further analysis of these effects. It would be desirable to follow rates of assimilation and rates of movement of dry matter at more frequent intervals during growth under controlled conditions.

In a number of cases (Radley, 1963; Goodwin, 1964) the size of the 'sink' in the form of the number of tubers is associated with the bulking rate, high tuber numbers resulting in high bulking rates. In these experiments there was little relationship between bulking rate and tuber number except in Majestic in Experiment 1 where a larger number of tubers was associated with a faster bulking rate.

It is not clear from these data whether the size of the 'source' or the size of the 'sink' determined the rate of bulking, especially in the unsprouted treatments of both varieties, where a low bulking rate was associated both with a low tuber number and a low rate of foliage growth.

7. Conclusions

1. Differences of 10-14 days in the time of maturity of the mother crop brought about by differences in the time of sprouting and differences in the dry matter contents of the mother tuber as a result of burning off are unlikely to affect subsequent growth and yield in either tubers set up to sprout before planting or tubers stored in bulk and unsprouted at planting time. Certainly any effect is very small compared with those differences arising from storage or sprouting in the winter immediately prior to planting.

2. Contrary to the results of Borah and Milthorpe (1959) and Radley, Taha and Bremner (1961), the rate of tuber bulking is not always constant throughout the bulking period. It is suggested that changes in the bulking rate could be related to the pattern of foliage growth and the prevailing weather conditions.

Note: The effects of storage and sprouting on sprout number, stem numbers, tuber numbers and yield will be considered in Chapter III when the results of Experiments 3, 4 and 5 can be included.

SECTION II

The effect of differences in sprout number and sprout development at the time of planting

a) Experiment 3 - 1965-66: Effects of desprouting

b) Experiment 4 - 1966-67: Effects of artificially induced differences in lateral branch development of the sprout

a) Experiment 3 - 1965-66

1. Introduction

The practice of desprouting results in a partial breakdown of apical dominance and an increase in sprout numbers (McCubbin, 1941; Toosey, 1962; Krijthe, 1962), stem numbers (McCubbin, 1941; Toosey, 1962) and tuber number (McCubbin, 1941; Fischnich, 1954; Sadler, 1961; Toosey, 1962). On regrowth after desprouting a greater number of sprouts grow more evenly, but after a time apical dominance is resumed (Krijthe, 1962; Morris, 1966). Emergence is similar in both sprouted and desprouted tubers (Krijthe, 1962) but senescence is often earlier in desprouted tubers (Krijthe, 1962). However, yield is only reduced where desprouting takes place just before planting (Sadler, 1961; Fischnich, 1954; Toosey, 1962). Grafting experiments (Madec, 1958) have demonstrated the influence of the mother tubers in determining the type of sprout produced; physiologically old tubers result in well-developed sprouts and physiologically young tubers, in poorly-developed sprouts. Desprouting these two types of tuber (Madec and Perennec, 1955) resulted in the regrowth of the original type of sprout.

The purpose of the experiment was to determine whether the effects of the loss of apical dominance by desprouting are the same as the effects of natural loss of apical dominance which occurs during cool storage, or whether additional effects occur, which might be exploited for increasing tuber number. In addition a treatment was included where differences in sprout development were induced artificially by removing the apex of sprouts before planting. The results of this treatment are presented in Section II, 7, Experiment 4.

2. Materials and methods

Certificate 'A' seed of both Arran Pilot and Majestic was sorted into 2 seed sizes (mean tuber weight 98 g and 59 g in Arran Pilot and 115 g and 65 g in Majestic) and treated in the following way.

1. Sprouted in December at 50^{o} - 55^{o}F, desprouted in January (February for Majestic) and resprouted at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.
2. Sprouted in January (February for Majestic) at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then transferred to 35^{o} - 45^{o}F till planting.
3. Sprouted in January at 50^{o} - 55^{o}F, desprouted in March and resprouted as 1 above.
4. Sprouted in March at 50^{o} - 55^{o}F and then as 3 above.

5. Sprouted in January at 50^{o} - 55^{o}F and the top 3 mm. of all sprouts clipped off in April. (The results of this treatment are presented in Section II, 7.2.4.)
6. No sprouting; stored at a constant temperature (40^{o}F) till planting.
7. No sprouting; stored at 35^{o} - 45^{o}F till planting when white sprouts were removed (only necessary in Arran Pilot).

Details of sprout development were recorded on 10 labelled tubers from each of the treatments and size classes on the following dates: 17/1/66, 25/1/67, 11/2/67, 9/3/67 (Arran Pilot only), 24/3/67 and 6/4/67 (Majestic only, and 19/4/66, and mainstem and lateral branch growth was followed on 3 of these tubers after planting. All the seed tubers were held in storage at 35^{o} - 45^{o}F prior to sprouting. During the sprouting phase an 8-hour day illumination was used and the trays were moved weekly to even out differences in the lighting pattern in the store. Storage temperatures are given in figure 2 of the Appendix. At planting time, the incidence of skin spot was recorded on the unsprouted tubers (table 1 of the Appendix). Sample tuber weights and dates of tray movement during storage are given in tables 2 and 3 of the Appendix respectively.

A split-plot design was used in the field with seed size on main plots, variety on sub-plots and treatments on sub sub-plots. There were three replicates. The experiment was laid out in the same field as Experiment 2. Planting took place on

5th May. Details of plot layout, manurial, cultural, weed and blight control practice were the same as for Experiment 2 (Section I, 2). Plot size for final harvest was $\frac{1}{460}$ acre. During the season a sample of 6 plants per plot was taken for counts of mainstems and stems at ground level. In addition an estimate of the severity of 'coiled-sprout' was made (Section I, 2). All plots were allowed to mature naturally and the final harvest took place on 11th October. Total yield and tuber number and weight and number of tubers in each of four size grades were recorded. Samples of about $\frac{1}{10}$ of the total plot weight were taken for dry matter determinations. Estimates of the date of 50% emergence and the date of 95% senescence were made from field scores carried out on 25th, 31st May, 6th and 9th June for emergence and 19th, 26th, 31st August and 5th, 12th, 19th and 23rd September for senescence.

3. <u>Results</u>

3.1. <u>Sprout growth during the storage period, sprout development at planting time and stem growth</u> (table 46 and figure 23)

3.1.1. <u>Sprout numbers, sprout length and stem numbers</u>

Seed tubers which were desprouted and then resprouted (T1 and T3) and seed tubers (T2 and T4) which were sprouted at the time T1 and T3-treated tubers were resprouted showed no difference in the number of sprouts per tuber, sprouts > 8 mm.

at planting or in the number of mainstems produced. In Arran Pilot desprouting in January (T1) compared with sprouting in January (T2) resulted in a greater degree of lateral-branch development of the sprouts at planting time and this was associated with an increase in the total number of stems at ground level. Desprouting in March in Arran Pilot (T3) compared with sprouting in March (T4) resulted in a greater total number of stems at ground level, but there was no evidence of a difference in sprout development at planting time. There were no significant differences in either of these characters in Majestic. Cold storage (T6) in Majestic resulted in a further loss of apical dominance compared with unsprouted tubers (T7) resulting in an increase in the number of mainstems. There was no significant effect in Arran Pilot but the results show a similar trend. Tubers first sprouted in January (February in Majestic) (T2) produced fewer sprouts per tuber and sprouts >8 mm. per tuber than March sprouting (T4). In neither variety were the effects significant. Mainstem numbers followed the same pattern but the effect was significant only in Arran Pilot, this probably being due to the greater time elapsing between the two dates of sprouting in Arran Pilot.

There were no significant differences in any of the sprouted treatments in total sprout length per tuber at planting time nor was there any indication of a faster rate of growth per sprout due to desprouting (figure 24).

Table 46 - Effect of sprouting and desprouting on sprout development at planting time, mainstem number and total stem number at ground level.

Treatment	Sprout number per tuber	Sprout number > 8 mm per tuber	No. lateral branches from sprouts	Mainstems per hill	Total stems per hill	% mainstems coiled
			ARRAN PILOT			
1	7.7	3.0	9.5	2.3	9.4	64
2	9.2	2.9	6.1	2.0	8.1	65
3	11.1	3.8	4.2	2.6	10.7	71
4	10.3	3.8	4.2	2.8	8.6	45
6	-	-	-	3.9	6.0	0
7	-	-	-	3.8	5.1	1
			MAJESTIC			
1	8.1	1.8	1.2	1.7	3.9	16
2	8.4	2.3	0.6	2.3	4.1	33
3	9.9	2.1	0.5	2.2	4.6	28
4	9.7	2.7	0.6	2.4	4.6	29
6	-	-	-	3.4	3.6	0
7	-	-	-	2.9	3.3	0
S.E.	±0.85	±0.33	±0.47	±0.15	±0.33	

Figure 23 Effect of sprouting and desprouting tubers on the change in sprout number with time.

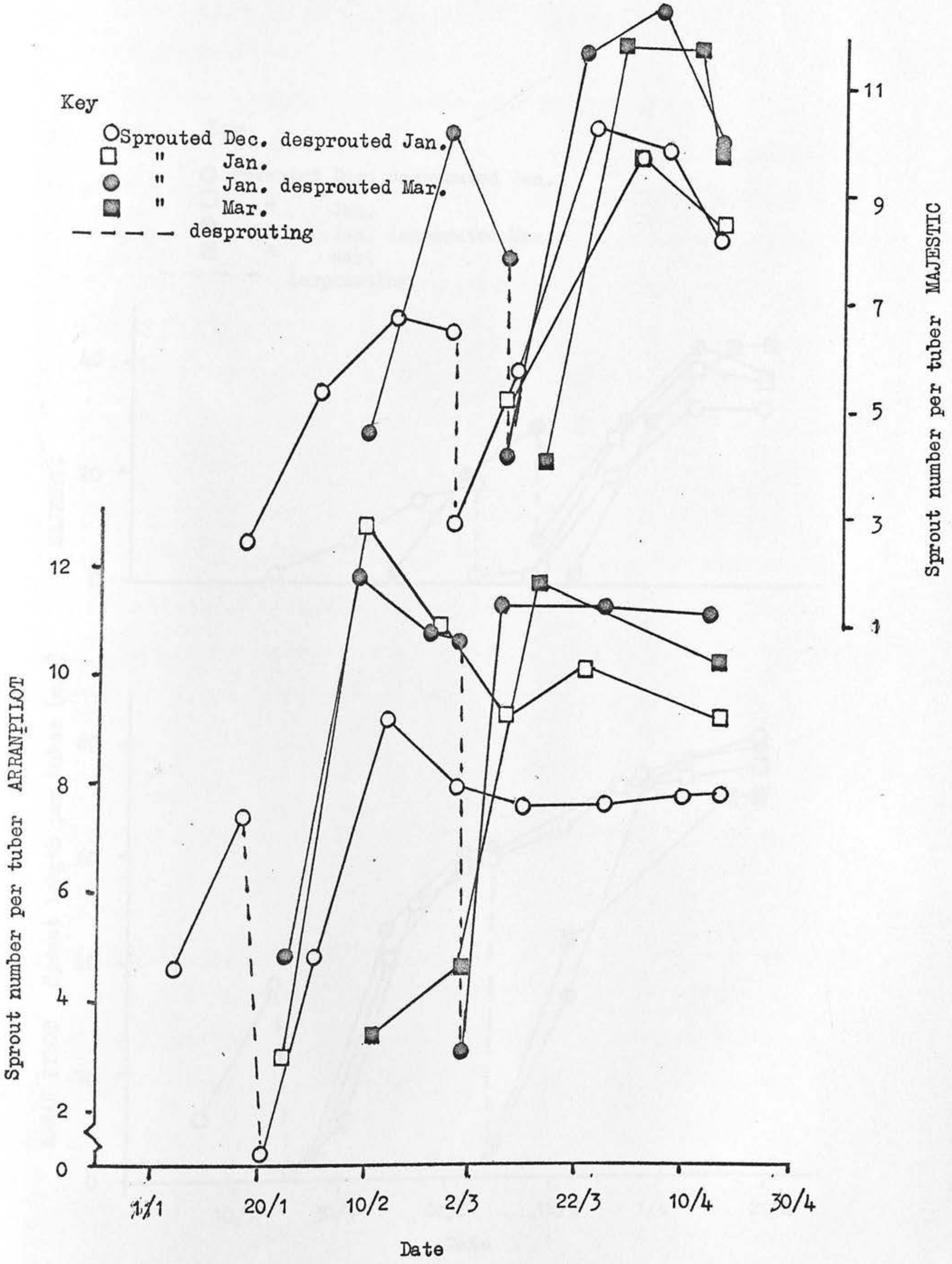
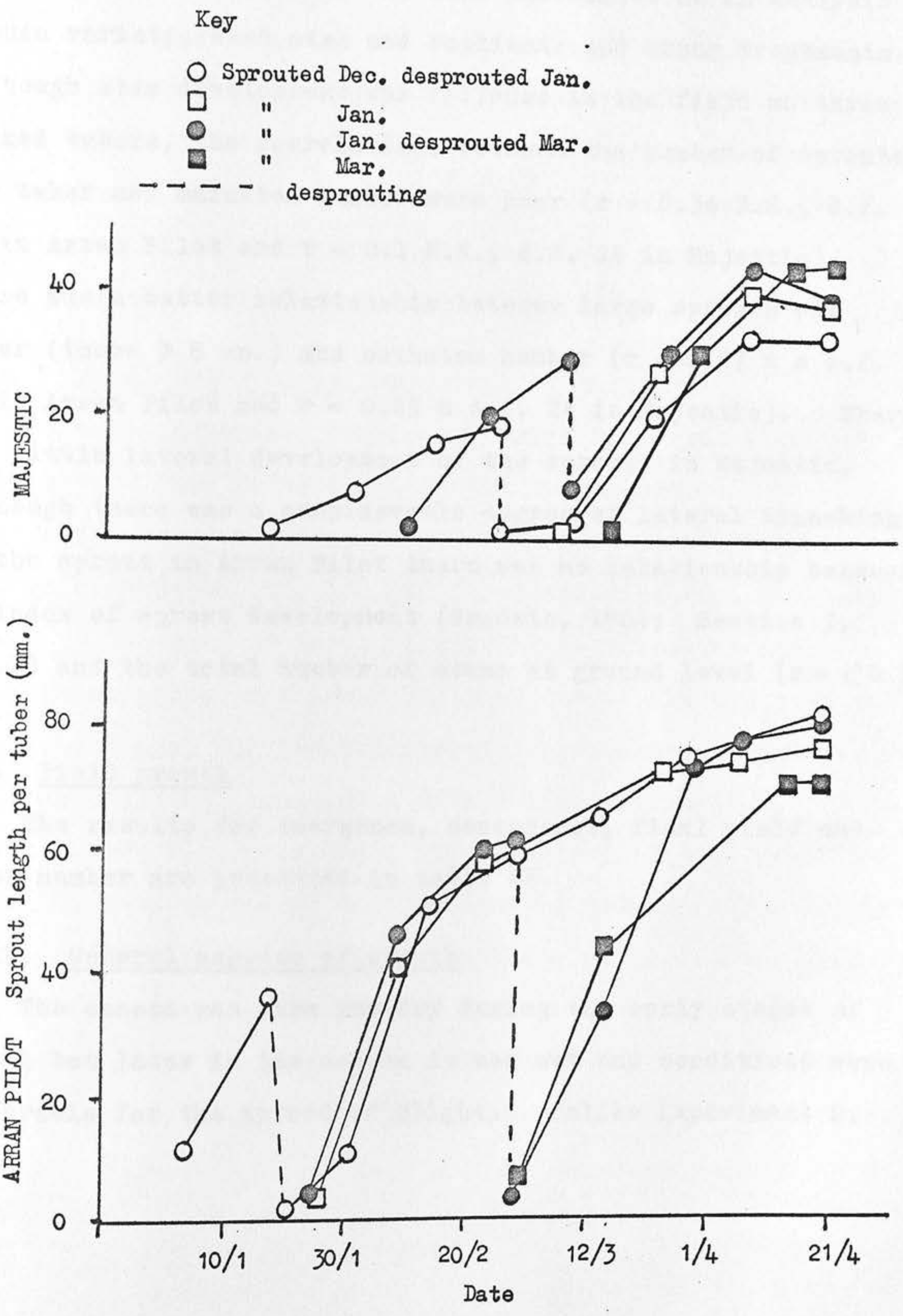


Figure 24 Effect of sprouting and desprouting tubers on the change in sprout length (mm.) with time.



3.1.2. The relationship between sprout number at planting time, sprout development at planting time and stem numbers

Correlation coefficients were calculated as an analysis within variety, seed size and replicate and among treatments. Although stem development was followed in the field on three marked tubers, the correlations between the number of sprouts per tuber and mainstem number were poor (r = 0.34 N.S., d.f. 24 in Arran Pilot and r = 0.1 N.S., d.f. 24 in Majestic). There was a better relationship between large sprouts per tuber (those > 8 mm.) and mainstem number (r = 0.57 ** d.f. 24 in Arran Pilot and r = 0.45 * d.f. 24 in Majestic). There was little lateral development of the sprouts in Majestic. Although there was a considerable degree of lateral branching on the sprout in Arran Pilot there was no relationship between an index of sprout development (Goodwin, 1964; Section I, 3.1.7) and the total number of stems at ground level (r = <0.1).

3.2. Field growth

The results for emergence, senescence, final yield and tuber number are presented in table 47.

3.2.1. General aspects of growth

The season was warm and dry during the early stages of growth but later in the season it was wet and conditions were favourable for the spread of blight. Unlike Experiment 2,

Table 47 - Effect of sprouting and desprouting on emergence, senescence, final yield and tuber number, dry matter percentage of tubers and dry matter yield.

	Date 50% emergence	Date 95% senescence	D.M. yield tons per acre	Dry matter percentage of tubers at harvest	Tuber yields (tons per acre)						Tuber numbers (thousands per acre)					
					Ware >$2\frac{1}{4}$"	Large seed $1\frac{3}{4}$-$2\frac{1}{4}$"	Small seed $1\frac{1}{4}$-$1\frac{3}{4}$"	Total seed $1\frac{1}{4}$-$2\frac{1}{4}$"	Chats <$1\frac{1}{4}$"	Total yield	Ware >$2\frac{1}{4}$"	Large seed $1\frac{3}{4}$-$2\frac{1}{4}$"	Small seed $1\frac{1}{4}$-$1\frac{3}{4}$"	Total seed $1\frac{1}{4}$-$2\frac{1}{4}$"	Chats <$1\frac{1}{4}$"	Total number
ARRAN PILOT																
1. Sprouted December desprouted January	30 May	16 Sept.	3.20	18.64	5.66	8.63	2.42	11.04	0.45	17.15	24.1	72.8	41.9	114.7	22.8	161.6
2. Sprouted January	2 June	8 Sept.	3.27	18.39	9.00	6.77	1.68	8.45	0.33	17.78	41.6	56.8	30.9	87.7	22.8	152.2
3. Sprouted January desprouted March	2 June	12 Sept.	3.28	18.57	7.60	7.77	1.89	9.66	0.45	17.70	34.2	68.8	34.7	103.6	24.4	162.2
4. Sprouted March	2 June	16 Sept.	2.87	18.50	7.58	5.85	1.75	7.60	0.34	15.52	32.6	49.7	31.3	81.0	22.0	135.6
6. Cold stored at 40°F	9 June	18 Sept.	2.49	16.97	6.26	6.53	1.66	8.20	0.26	14.71	27.8	55.8	29.0	84.7	14.4	127.0
7. No sprouting; stored at 35°-45°F till planting	7 June	18 Sept.	2.98	17.92	8.82	6.24	1.39	7.63	0.24	16.69	36.3	52.8	25.9	78.7	13.8	128.9
MAJESTIC																
1. Sprouted December desprouted February	1 June	23 Sept.	3.55	19.53	10.19	6.33	1.34	7.67	0.33	18.18	41.4	51.8	23.4	75.2	18.7	135.4
2. Sprouted February	2 June	23 Sept.	3.82	20.17	10.92	6.43	1.29	7.72	0.33	18.97	43.9	51.3	24.0	75.4	19.5	138.7
3. Sprouted January desprouted March	1 June	23 Sept.	3.76	20.42	10.41	6.09	1.59	7.68	0.36	18.45	41.0	48.4	27.6	76.0	20.4	137.5
4. Sprouted March	2 June	23 Sept.	3.62	20.60	10.24	5.59	1.41	7.00	0.33	17.56	40.2	47.2	24.9	70.1	21.4	131.7
6. Cold stored at 40°F	11 June	29 Sept.	2.99	18.78	8.06	6.19	1.35	7.55	0.29	15.90	33.2	51.2	22.7	74.0	17.5	124.7
7. No sprouting; stored at 35°-45°F till planting	7 June	27 Sept.	3.58	19.57	10.51	5.95	1.39	7.34	0.38	18.23	41.4	48.9	24.7	73.7	17.4	132.4
Standard errors			±0.131	±0.303	±0.617	±0.287	±0.106	±0.327	±0.039	±0.651	±2.41	±2.58	±1.86	±3.49	±2.26	±5.10

storage (T6) was accentuated by a decrease in percentage dry matter of the tubers compared with the other treatments.

There was no significant effect of treatment on total tuber number in Majestic. Arran Pilot, however, proved more responsive to the treatments. March-desprouting (T3) compared with first-sprouting (T4) resulted in an increase in total tuber number (12%). January-desprouting (T1) compared with first-sprouting (T2) resulted in a similar but non-significant increase in total tuber number. January-sprouting (T2) produced 15% more tubers than March-sprouting (T4) and 19% more tubers than unsprouted (T7) or cold-stored (T6) tubers.

3.2.3. <u>Graded tuber yields and tuber numbers</u> (Table 47)

There were no significant effects of treatment on graded yield or number in Majestic with the exception of T6 where there was a reduction in ware yield.

In Arran Pilot January-desprouting (T1) gave a 30% greater yield of seed and a 15% reduction in the yield of ware than first-sprouting in January (T2), largely as a result of the increase in total tuber number. But in March-desprouting (T3) there was little increase in seed yield although there was an increase in total tuber number over first-sprouting in March (T4), largely as a result of the reduction in total yield with T4 which affected the proportion of tubers falling into the ware category. With cold-storage (T6), which produced a similar number of tubers to the unsprouted treatment (T7), the reduction in total yield was reflected largely by a reduction in yield in the ware category. The pattern of graded tuber numbers followed the pattern of grading by weight closely.

3.2.4. <u>The relationship between stem numbers and tuber numbers</u>

All correlation coefficients were calculated as an analysis within variety, replicate and seed size and among treatments.

In Majestic there was very little variation in either stem or tuber number as a result of the treatments and no significant relationship could be established between mainstem number and tuber number ($r = < 0.1$ N.S., d.f. 30) or the total number of stems at ground level and tuber number ($r = 0.26$ N.S., d.f. 30). In Arran Pilot, where there was more variation in stem and tuber number, there was a significant negative relationship between tuber number and mainstem number ($r = -0.91$ ✻ ✻, d.f. 30). This was largely due to the lower tuber number and higher mainstem number for the two unsprouted treatments (T6 and T7) compared with the sprouted treatments (T1, T2, T3, T4 and T5). The relationship between mainstem and tuber number within the sprouted treatments T1, T2, T3, T4 and T5 was poor. There was a positive relationship ($r = 0.43$ ✻, d.f. 30) between the total number of stems at ground level and total tuber number. When only the sprouting treatments are considered the relationship is improved ($r = 0.50$ ✻ ✻, d.f. 18).

4. Discussion

The practice of desprouting tubers results in a loss in apical dominance and an increase in sprout numbers, stem numbers and tuber numbers (McCubbin, 1941; Toosey, 1962; Krijthe, 1962; Sadler, 1961; Fischnich, 1954). The treatments in this experiment which can be compared in this way, T2 and T3 in Arran Pilot, show similar results but in Majestic since T2 was not set up to sprout at the same time as T3 the results are not strictly comparable although they do indicate that desprouting in March results in a further loss in apical dominance over February sprouting. Emergence in desprouted and sprouted tubers was similar though in Arran Pilot there was evidence of earlier senescence in desprouted tubers. The reduction in yield (2 tons per acre in a 16 tons per acre crop in Arran Pilot and 2.3 tons per acre in an 18 tons per acre crop in Majestic), which was associated with a reduction in the number of tubers, resulting from cold storage (T6) compared with unsprouted tubers (T7) cannot be readily explained by the small differences in the time of emergence and maturity. A yield reduction associated with a reduction in tuber numbers also occurred in T4 compared with T2 in Arran Pilot. No explanation can be offered for these effects since foliage and tuber growth were not followed closely.

It is not clear whether the decline in apical dominance brought about by desprouting has the same effect on sprout growth and field growth as the decline in apical dominance brought about by delaying the time of setting up for sprouting. In this connection the comparisons of desprouted tubers and tubers set up to sprout at the time of desprouting are of interest. Desprouting in this case did not result in an increase in sprout or mainstem number in either variety. However, there resulted, on regrowth of the sprouts in desprouted tubers, a greater degree of sprout development at planting time than in first sprouted tubers in Arran Pilot. This increase in sprout development was associated with an increase in the total number of stems at ground level and tuber numbers in the field. Consequently, seed yield was greater from desprouted tubers (about 12%) than those tubers first sprouted at the time of desprouting. The response was similar for both dates of desprouting. None of these effects could be demonstrated in Majestic. Possibly the difference in response between the two varieties in tuber number to differences in mainstem and total stem density is a reflection of their differing capacities for stem production, Arran Pilot producing many mainstems and branches and Majestic very few.

Madec (1958) suggested that the type of sprout produced could be influenced by the state of the tuber tissues at the start of bud growth, physiologically older tubers producing sprouts with a greater degree of lateral branch development than physiologically younger tubers. Since seed tubers which have been desprouted and then resprouted (T1 and T3) are physiologically older than tubers sprouted when the T1 and T3-

treated tubers were sprouted, the response in stem and tuber number to sprouting may have been modified by the condition of the tuber tissues at the start of sprout growth. Although care was taken to remove all the sprout tissue at desprouting, the possibility that partial removal of the sprouts causing damage to apex resulting in the promotion of lateral branch development, cannot be ruled out.

In both Arran Pilot and Majestic, T6 produced a greater number of stems than T7 but fewer tubers. Toosey (1962) has noted that cold storage of tubers at 35°F before planting compared with storage of tubers between 35° - 45°F results in a reduction in tuber number. Radley (1963) and Goodwin (1964) have shown that tuber initiation later in the season can result in a reduction in tuber number. Although dates of tuber initiation were not determined, emergence in T6 was later than T7, suggesting a later date of initiation.

b) Experiment 4 - 1966-67

5. Introduction

Large sprouts produce more tubers than small sprouts (Wakankar, 1944) due to a greater degree of sprout development at the time of planting (Morris, 1966). Secondary stems arising from lateral branches on the sprout do produce tubers (Borah and Milthorpe, 1959; Das Gupta, 1962; Experiment 1, Section II) and these lateral branches on a single well-developed sprout can compensate in tuber number for a number of poorly-developed sprouts showing weak lateral-branch development or for numerous stems arising from unsprouted seed (Das Gupta, 1962; Toosey, 1963; Experiment 1, Section II).

Goodwin (1964) has shown a relationship between an index of sprout development at planting time (defined as the number of stolons + lateral aerial branches on the sprouts + sprouts per tuber) and the total number of stems at ground level and also tuber number, an increase in sprout development resulting in an increase in stem and tuber numbers. Although Wassink et al. (1950) found that an increase in light intensity during storage resulted in an increase in sprout development at planting time, Shotton (Terrington E.H.F., 1961, 1962) did not find any evidence of an effect on total or graded yields.

Gregory and Veale (1957) produced, by removing the apex of flax plants at various stages of growth or by varying the level of decapitation, different ratios between basal and anterior branches. Early decapitation led to the development of basal branches and late decapitation to the production of anterior laterals.

The maintenance of the diageotropic habit of the stolons, in the potato, may involve an interaction between auxins translocated from the apex and gibberellic acid produced in the tuber or root system (Booth, 1963). Decapitation of the apex results in the stolon-like basal branches turning into leafy branches (Booth, 1959), presumably as a result of the removal of the source of auxin. The effects of changes in the morphology of the sprout system on stem and tuber development were not described.

Morris (1966) showed that with an increase in tuber size there was an increase in the total number of stolons and leafy branches and an increase in the proportion of leafy branches to total branches, but with an increase in the number of sprouts per tuber there was a decrease in the proportion of leafy branches per sprout. The effects on tuber number were not described.

The purpose of Experiment 4 was to investigate the effect of different types of morphological development of sprouts on stem and tuber production. It was hoped that clipping the apex off single sprouts at different stages of sprout development would produce differences in lateral branch growth and tuber production.

6. Materials and methods

Arran Pilot F.S. seed was graded into three seed sizes, mean weights of 117, 79 and 50 g., and further divided into the following 8 treatments.

1. Sprouted in November at 50^{o} - 55^{o}F till the sprouts were 1 cm. long and then to 40^{o}F till planting.
2. Sprouted in November at 50^{o} - 55^{o}F till the sprouts were 1 cm. long when all sprouts except the apical sprouts were removed, and then to 40^{o}F till planting.
3. As 2 above and apical 3 mm. of the sprout removed in January.
4. As 2 above but apical 3 mm. of the sprout removed in February.
5. Sprouted in March at 50^{o} - 44^{o}F till the sprouts were 1 cm. long and then to 40^{o}F till planting.
6. Sprouted in March at 50^{o} - 55^{o}F till the sprouts were 1 cm. long when all the sprouts (except the apical sprout) were removed, and then to 40^{o}F till planting.
7. As 6 above and apical 3 mm. of the sprout removed in March.
8. As 6 above but apical 3 mm. of the sprout removed in April.

Ten tubers of approximately average weight from each seed size and treatment were marked, and sprout numbers and sprout development recorded at planting time. Tubers were cool stored at 35^{o} - 45^{o}F to prevent premature sprout growth until required for sprouting. An 8-hour day illumination was used during sprout growth and the trays were moved weekly to even out differences in the lighting pattern in the store. Storage temperatures are shown in figure 3 of the Appendix. Sample tuber weights, dates of movement of trays and dates of clipping are given in tables 2 and 3 of the Appendix. In all cases the top 2-3 mm. of the single sprout was removed, irrespective of the size of the sprout, which varied, and it is possible that different numbers of apices were removed from each tuber by this operation.

The field experiment was of split-plot design with seed size in main plots and the 8 treatments in sub-plots. There were three replicates. The experiment was laid down on the University Farms on a gravelly, sandy loam at 400' elevation. Ten tons of F.Y.M. was applied in early spring and ploughed in. Eighty units of N and P_2O_5 and 100 units of K_2O per acre were broadcast after working on 31st March. Planting was carried out on 17th April in ideal conditions, and covered by ridging. Weeds were controlled by spraying with linuron (2 lb./acre A.I.) in 30 gallons of water on 5th May. Protective blight spraying was carried out on 18th, 28th July and 17th August. In the layout of the experiment, provision was made for tractor spraying without causing damage to the plots (Section I, 2). All plots were allowed to mature naturally, and final harvest took place on 16th October. Total yield and tuber number and weight and number of tubers in each of four size grades were recorded. Samples of about $\frac{1}{6}$th of the weight of the final harvest were taken for dry matter determination. Plot area harvested was $\frac{1}{460}$ acre. In addition, 6 plants were taken on 13th June to record numbers of mainstems and total stems at ground level. An estimate of the incidence of 'coiled-sprout' was made (Section I, 2). Estimates of the date of 50% emergence and the date of 95% senescence were obtained from field scores carried out on the following dates: for emergence, 8th, 10th, 13th, 17th, 25th and 31st May, and for senescence, 7th, 23rd and 28th August and 2nd, 7th and 13th September.

7. Results

7.1. Sprout and stem data (tables 48, 49, 50, 51)

7.1.1. Sprout development at planting time and stem growth (plate 1)

Well-developed sprouts produce two types of lateral branches: 1) negatively geotropic branches with some expansion of the leaves, which generally form nearer the apex of the sprout, and 2) diageotropic stolon initials with hooked tips and little leaf expansion, which generally form nearer the base of the sprout. In the present experiment the two types of branch are referred to as 1) leafy branch and 2) stolon-like branch.

November-sprouting (T1) produced fewer, more highly developed sprouts by planting time than March-sprouting (T5). As a result November-sprouted tubers produced fewer, more

Table 48 - Effect of sprout treatment on sprout development per tuber at planting time.

		Sprout number per tuber	Sprout length per tuber (mm)	Total number of stolons and leafy branches + sprouts (index sprout development)	Total number of leafy branches + stolons	Total number of leafy branches	Total number of stolons	Ratio of leafy branches to leafy branches + stolons
T 1	Sprouted November	5.6	71.1	12.1	6.4	3.4	3.0	0.53
2	November produced single sprouts - control	1.0	56.9	7.2	6.2	3.6	2.5	0.58
3	November produced single sprouts - clipped early	1.0	48.6	7.7	6.7	4.3	2.4	0.64
4	November produced single sprouts - clipped late	1.0	24.5	8.4	7.4	5.8	1.6	0.78
5	Sprouted March	9.2	74.7	11.6	2.4	0.4	2.0	0.17
6	March produced single sprouts - control	1.0	24.3	4.4	3.4	1.5	1.9	0.44
7	March produced single sprouts - clipped early	1.0	16.2	5.1	4.1	2.5	1.6	0.61
8	March produced single sprouts - clipped late	1.0	17.3	4.7	3.7	1.6	2.1	0.43
	S.E.s	±0.43	±3.52	±0.21	±0.46	±0.37	±0.46	

Table 49 - Effect of sprout treatment and seed size on the number of leafy branches (L) and the number of stolons (S) per tuber and the ratio of leafy branches to the total number of leafy branches and stolon-like branches (R) and tuber number (T) in thousands per acre.

	Large				Medium				Small				Mean			
	L	S	R	T	L	S	R	T	L	S	R	T	L	S	R	T
T 1	3.1	3.1	0.50	121.2	4.3	1.5	0.74	110.3	2.9	4.4	0.40	104.8	3.4	3.0	0.53	112.1
T 2	3.8	2.5	0.60	115.5	4.3	2.7	0.61	102.0	2.8	2.4	0.54	96.9	3.6	2.5	0.58	104.8
T 3	4.2	2.7	0.61	99.4	4.7	2.3	0.67	102.8	4.1	2.2	0.65	97.7	4.3	2.4	0.64	100.0
T 4	6.4	1.4	0.82	101.1	6.0	1.6	0.79	98.8	4.9	1.8	0.73	92.2	5.8	1.6	0.78	97.4
T 5	1.2	3.0	0.28	136.5	0.0	1.4	0.00	132.4	0.1	1.5	0.06	112.6	0.4	2.0	0.17	127.2
T 6	2.2	1.9	0.54	101.7	1.4	1.5	0.48	89.4	0.8	2.4	0.25	88.0	1.5	1.9	0.44	93.0
T 7	2.4	1.1	0.68	93.4	3.0	2.0	0.60	90.6	2.2	1.7	0.56	84.5	2.5	1.6	0.61	89.5
T 8	1.8	2.3	0.44	99.8	1.9	2.0	0.49	92.5	1.0	2.0	0.33	86.3	1.6	2.1	0.43	92.9
Mean	3.1	2.3	0.57	108.6	3.2	1.9	0.63	102.3	2.4	2.3	0.51	95.3	2.9	2.1	0.58	102.1

Table 50 - Effect of sprout treatment on mainstems, the total number of stems at ground level and the number of lateral branches.

Treatment	Mainstems per hill	Total stems at ground level per hill	Branch stems per hill
1	1.6	7.8	6.3
2	1.1	6.1	5.0
3	1.0	6.4	5.4
4	1.1	5.8	4.7
5	3.2	8.7	5.5
6	1.3	4.9	3.6
7	1.2	4.6	3.4
8	1.3	4.3	3.0
S.E.s	±0.10	±0.33	±0.31

Table 51 - Effect of seed size on sprout development, stem and tuber production.
(averaged over all treatments)

Seed size	Sprout number per tuber	Sprout length per tuber (mm)	Number of leafy branches + stolons	Mainstems per hill	Total stems per hill	Tuber yield (tons per acre)	Tuber number per acre
Large	3.0	46.8	5.4	1.6	7.1	17.95	108,611
Medium	2.5	42.7	5.1	1.5	6.1	17.37	102,369
Small	2.3	35.6	4.7	1.3	5.0	16.96	95,397
S.E.	±0.15	±1.24	±0.16	±0.06	±0.24	±0.329	±2,088

PLATE 1

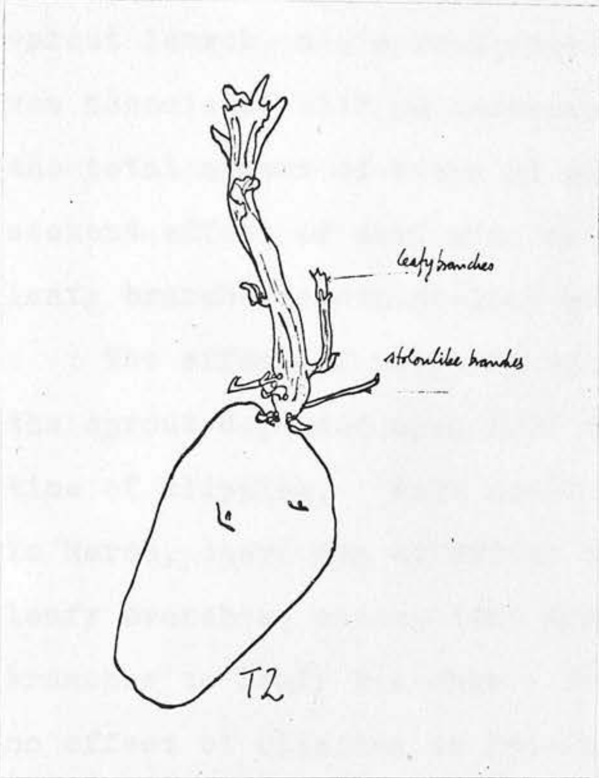
Drawings of sprouts of Arran Pilot showing the effects of clipping on sprout development.

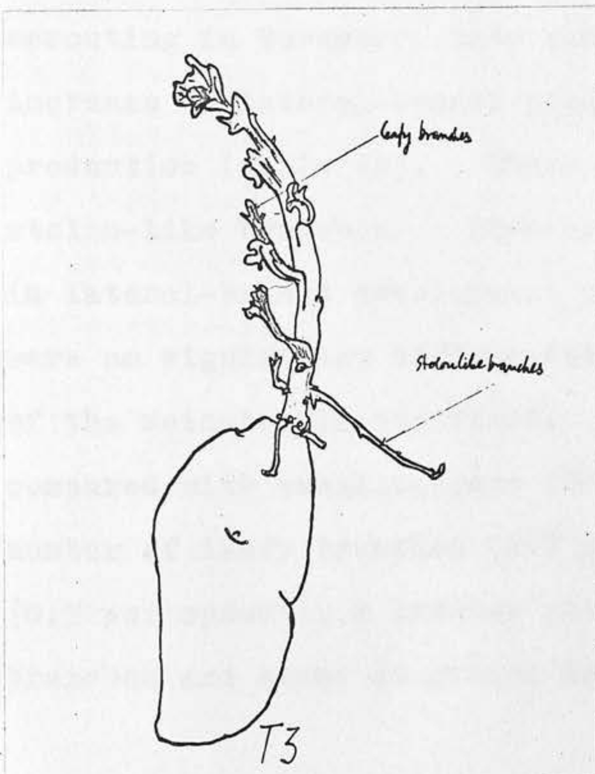
Key

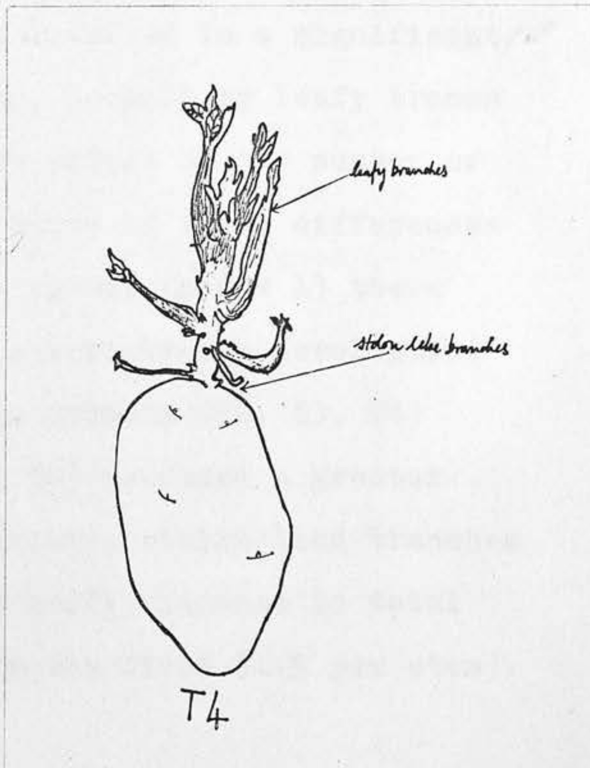
T2 Sprouted in November and all sprouts except the apical sprout removed when the sprouts were 1 cm.

T3 As T2 and then 3mm. of tissue was clipped off the apex of the sprout in January.

T4 As T2 and then 3mm. of tissue was clipped off the apex of the sprout in February.







0 20 40 60 80

Scale mm.

highly branched mainstems than March-sprouted tubers. An increase in seed size resulted in an increase in sprout number, sprout length, and sprout development at planting time. This was associated with an increase in the number of mainstems and the total number of stems at ground level. There was no consistent effect of seed size on the ratio of leafy branches to leafy branches + stolon-like branches.

The effect of clipping on lateral-branch development of the sprout depended upon both the size of the sprouts and the time of clipping. With small sprouts, produced by sprouting in March, there was no effect of clipping on the number of leafy branches, stolon-like branches or the ratio of leafy branches to leafy branches + stolon-like branches. There was no effect of clipping on lateral-branch production on the mainstem in the field. With large sprouts, produced by sprouting in November, late clipping resulted in a significant increase in lateral-branch production, largely by leafy branch production (table 48). There was no effect on the number of stolon-like branches. However, in spite of these differences in lateral-branch development of the sprout (plate 1) there were no significant differences in lateral-branch development of the mainstem in the field. Large sprouts (T2, T3, T4) compared with small sprouts (T6, T7, T8) produced a greater number of leafy branches (2.7 per sprout), stolon-like branches (0.3 per sprout), a greater ratio of leafy branches to total branches and stems at ground level in the field (1.5 per stem).

Within the clipping treatments the variation in sprout and stem morphology was low and as a result there was little relationship between an index of sprout development (Section I, 3.1.7) and the total number of stems at ground level but, when among treatment variation is considered, a significant positive relationship between the index of sprout development and the total number of stems at ground level resulted ($r = 0.95$ **, d.f. 6 - calculated from the mean values for each treatment averaged over seed size and replicate).

7.2. <u>Field growth</u>

7.2.1. <u>General aspects of growth</u>

Early growth was slow due to the wet, cold conditions after planting (table 4 of the Appendix). Dry conditions occurred during the period of tuber formation and during the early bulking phase of growth. There was virtually no blanking, though emergence was erratic. Blight was absent and there was little tuber disease at harvest. There was no effect of treatment on either the date of 50% emergence, or 95% senescence (table 52).

7.2.2. <u>Total tuber yield and number</u> (table 53)

There was no effect of the time of sprouting (T1 compared with T5) on total yield, but November-sprouting (T1) produced significantly fewer tubers. An increase in seed size (table 51) resulted in a small but non-significant increase in tuber

Table 52 - Effect of sprout treatment on the date of 50% emergence and 95% senescence.

Treatment	Emergence	Senescence
1	25 May	7 September
2	25 May	7 September
3	26 May	7 September
4	24 May	6 September
5	26 May	6 September
6	27 May	7 September
7	25 May	6 September
8	26 May	7 September

yield and an increase in tuber number. November-sprouted single-sprouts (T2, T3, T4) produced a significantly greater total yield of tubers and number of tubers (15.5 ± 3.5 thousand per acre) than March-sprouted single-sprouts (T6, T7, T8). For November- and March-single-sprouts, progressively later clipping led to progressive reductions in total yield, and for the November-single-sprouts this was associated with a reduction in tuber numbers. However, none of the effects were significant. There was no effect of treatment on tuber dry matter percentage at harvest (table 54).

7.2.3. Graded tuber yields and numbers (table 53)

There was no significant effect of the time of sprouting (T1 compared with T5) on ware, seed or chat yields though there was a tendency for March-sprouting (T5) to produce more seed and less ware than November-sprouting (T1). The progressive reductions in total yield in the November- and March-single-sprouts with delay in clipping were largely accounted for by the reduction in ware yield but this was only significant in the T2 v. T4 comparison. There were no consistent effects on seed or chat yield. The pattern of tuber number in grades followed the pattern of tuber yield in grades closely.

7.2.4. Effect of removing the apex of sprouts before planting on branch development, tuber number and yield in 1965-66

An extra treatment was included in Experiment 3, treatment 5, in which the apex was clipped off all the sprouts before

Table 53. - Effect of sprout treatment on tuber yield and tuber number.

Treat-ment	Tuber yield (tons per acre) Ware $>2\frac{1}{4}$"	Large seed $1\frac{3}{4}-2\frac{1}{4}$"	Small seed $1\frac{1}{4}-1\frac{3}{4}$"	Total seed $1\frac{1}{4}-2\frac{1}{4}$"	Chats $<1\frac{1}{4}$"	Total tuber yield	Tuber number (10^3 per acre) Ware $>2\frac{1}{4}$"	Large seed $1\frac{3}{4}-2\frac{1}{4}$"	Small seed $1\frac{1}{4}-1\frac{3}{4}$"	Total seed $1\frac{1}{4}-2\frac{1}{4}$"	Chats $<1\frac{1}{4}$"	Total tuber number
1	11.97	4.50	0.72	5.22	0.25	17.44	44.0	41.7	14.6	56.3	11.8	112.1
2	14.90	3.56	0.63	4.20	0.25	19.34	49.1	32.0	12.3	44.3	11.5	104.8
3	13.81	3.77	0.55	4.32	0.24	18.37	45.7	33.4	10.7	44.2	10.1	100.0
4	11.97	4.14	0.64	4.78	0.20	16.95	39.1	36.4	11.6	47.9	10.3	97.4
5	10.83	5.18	0.93	6.11	0.39	17.33	39.8	48.9	19.3	68.2	19.1	127.2
6	13.37	3.50	0.57	4.07	0.19	17.63	43.4	32.2	9.5	41.6	8.0	93.1
7	12.55	3.29	0.51	3.81	0.16	16.52	42.7	29.4	9.5	38.9	7.9	89.5
8	11.70	3.35	0.61	3.96	0.19	15.85	41.7	29.8	11.7	41.5	9.7	92.9
S.E.s	±0.895	±0.288	0.087	0.324	0.062	±0.873	±3.23	±2.50	±1.71	±3.46	±2.82	±4.99

planting, and the results are presented here.

Removal of the apex of all the sprouts resulted, in Arran Pilot but not Majestic, in a small increase in the number of lateral branches arising below ground from the mainstem but, in spite of this, possibly as a result of a reduction in the number of mainstems which was found with clipping, there was a reduction in tuber number compared with the control.

Table 54_a - Effect of clipping off the apex of all the sprouts before planting (T5) compared with the control (T2) on sprout number, sprout development at planting time, stem numbers and tuber number and yield.

	Sprout number per tuber	Sprouts >8 mm per tuber	Number of lateral branches per sprout	Main-stems per hill	Total stems per hill	Total yield (tons per acre)	Total tuber number (thousands per acre)
			ARRAN PILOT				
T2	9.2	2.9	6.1	2.0	8.1	17.78	152.2
T5	9.8	2.1	6.5	1.9	7.0	17.53	128.7
			MAJESTIC				
T2	8.4	2.3	0.6	2.3	4.1	18.97	138.7
T5	7.7	1.0	0.2	1.9	4.6	17.39	124.6
S.E.	±0.85	±0.33	±0.47	±0.15	±0.33	±0.651	±5.10

7.2.5. The relationship between stem number and tuber number

There was a poor relationship between mainstem and tuber numbers when all the treatments were considered, but March-sprouted tubers (T5) produced more mainstems and tubers than November-sprouted tubers (T1). Within the clipping treatments the variation in stem and tuber number was small and as a result the relationship between the total number of stems at ground level and tuber number was poor but among treatments an increase in the total number of stems at ground level was associated with an increase in tuber number (r = 0.43 ✱ ✱, d.f. 54 - calculated as an analysis within seed size and replicate and among treatments).

8. <u>Discussion</u>

Morris (1966) found that an increase in seed size resulted in an increase in the size and lateral development of the sprout accompanied by an increase in the ratio of leafy branches to the total number of leafy branches + stolon-like branches on the sprout. The change from the stolon-like habit to the leafy-branch habit did not appear to take place at a predetermined node number. In this experiment an increase in seed size resulted in an increase in lateral branch development but there did not appear to be any consistent difference in the ratio of leafy branches to total branches, the number of leafy branches or the number of stolon-like branches with an increase in seed size.

Although the linear relationship between the total number of stems at ground level and tuber number removed only 20% of the variance in tuber number it was significant ($p > 0.01$). The effect of clipping on sprout morphology and lateral-branch development was small and did not result in a significant difference in tuber numbers. However, larger differences in sprout development and stem numbers as produced between November-produced single sprouts and March-produced single sprouts did have a significant effect on tuber number: $(T2 + T3 + T4) - (T6 + T7 + T8) = 15.5$ thousand tubers per acre ± 3.52, an increasing degree of lateral-branch development resulting in an increase in stem and tuber number.

The progressive though non-significant decrease in yield and tuber number from clipping the November-produced single sprouts and decline in yield from clipping the March-produced single sprouts may be associated with the decrease in sprout length that accompanied delay in clipping. Headford (1961) and Sadler (1961) found that an increase in sprout length up to 2.5 cm., and Burrage (1966) an increase up to 5 cm. in Arran Pilot, resulted in an increase in yield.

9. Conclusions

1. The practice of desprouting tubers results in a loss of apical dominance, an increase in sprout number and, in the field, stem number and tuber number in both Arran Pilot and Majestic.

2. The effects of desprouting tubers on the decay of apical dominance appear to be the same as the effects arising from a delay in setting up tubers to sprout on sprout and mainstem number in both Arran Pilot and Majestic. There are indications from this experiment that, in Arran Pilot but not Majestic, desprouting results in an increase in lateral-branch development and this is associated with a small increase in tuber number and seed yield.

3. The results from the clipping experiment suggest that tip-death of sprouts with the resulting change in the branching habit of the sprouts is unlikely to have a large effect on stem or tuber production.

N.B. The effects of date of sprouting on sprout number, tuber number and yield and the relationship between sprout characters, stem characters and tuber number will be considered in Chapter III.

SECTION III

The effect of the environment in the early stages of post-emergence growth

Experiment 5: Planting date experiment 1967
Experiment 6: Shading experiment 1968

Experiment 5

1. Introduction

The relative performance of sprouted and unsprouted tubers in tuber production varies considerably from year to year but the effect of sprouting on mainstem number shows a consistent pattern, unsprouted tubers producing more than sprouted tubers (Introduction, table 1).

Variation in tuber number irrespective of mainstem density has been shown to occur in planting date experiments (Radley, 1963) and in irrigation experiments (Peeler, 1966; Llewellyn, 1967). Under constant mainstem densities variation in the number of tubers may depend upon the number initiated (Radley, 1963; Burrage, 1965; Bremner and Radley, 1966; Llewellyn, 1967) or on the rate of tuber loss (Radley, 1963; Simpson *et al*., 1965), both of which may show variation with the date of planting (Radley, 1963) or with different irrigation regimes (Llewellyn, 1967). Different nutrient regimes (Hanley *et al*., 1965; Will, 1966) and type of nutrient (Hanley *et al*., 1965; Simpson *et al*., 1965; Armitage, 1965, 1966) also affect the number of tubers formed and surviving, but it is not clear whether the differences in the number of tubers initiated, as a result of different nutrient regimes and type of nutrient, occurred irrespective of changes in mainstem density, since Armitage (1966) showed that the effects of KCl and K_2SO_4 on tuber numbers were associated with changes in mainstem number.

Increasing air temperature (Bushnell, 1925), soil temperature (Yamaguchi et al., 1964; Epstein, 1966), decreasing light intensity and a decreasing daylength (Driver and Hawkes, 1943; Pohjahkallio et al., 1957) and an increasingly inadequate soil water supply (Pratt, 1952; Steineck, 1958; Peeler, 1966; Llewellyn, 1967) result in a progressive reduction in tuber number.

The effect of temperature on growth and development depends upon the stage of development at which exposure occurs (Burt, 1961, 1964a). Epstein (1966) could show no effect on tuber number when root temperatures were kept at 48°F and 72°F during the early stages of growth but there was a larger effect on tuber number and yield with exposure to these temperatures after tuber initiation, a decrease in tuber number and an increase in yield resulting from an increase in root temperature. Similarly the response in tuber yield to irrigation was greatest at the time of tuber initiation and during the linear phase of bulking rather than at the time of stolon swelling, but the response in tuber number was greatest when irrigation occurred at the time of stolon swelling (Llewellyn, 1967).

Sprouted seed emerges 7-10 days earlier than unsprouted seed (Toosey, 1964; J.C. Holmes, unpublished results; Experiments 1 and 2, Section I, and Experiment 3, Section II) and thus encounters different environmental conditions in the early stages of growth. Thus the relative performance of sprouted and unsprouted tubers in respect of tuber number may be confounded with the effects of the environment in the early stages of growth.

From the work of Fischnich and Krug (1963), using seed sprouted at 12°C, 8°C and 5°C and seed stored at 2°C and planted in the field at different dates, there is an indication that the response in yield to the treatment was not dependent upon the date of emergence in seed sprouted at 8°C but was in seed sprouted at 5°C, 12°C or cold stored (2°C), where progressively later emergence resulted in a decline in yield. However, the effects of treatment on tuber number were not described.

The purpose of Experiment 5 was to determine the effects of planting sprouted and unsprouted tubers at 2-day intervals over a period of 28 days on tuber formation and survival, tuber growth, foliage growth and tuber number and weight at harvest under constant stem development attempting to relate any changes in growth and tuber number to differences in the environment in the early stages of growth. Efforts were made to minimise changes in sprout development over the planting period by keeping the tubers in a cool store (40°F).

2. <u>Materials and methods</u>

Scottish F.S. Grade Majestic seed, previously stored at 35° - 45°F, was sorted into 3 seed sizes (mean tuber weights 123.4 g.; 77.6 g.; and 45.0 g.). Sample tuber weights are given in the Appendix, table 2. Each of these size groups was divided for the sprouted and unsprouted treatments and further divided to provide for 14 dates of planting at 2-day intervals in the field. A sample of 10 tubers from each treatment was marked, and records of sprout development for each date of planting in both sprouted and unsprouted tubers were taken at 2-day intervals from 3rd - 29th April inclusive. An assessment of the degree of skin-spot infection was made on the unsprouted tubers just before planting (Appendix, table 1). Unsprouted treatments were stored at 35° - 45°F in light-proof boxes. The sprouted treatments were set up under an 8 hr. day illumination at 50° - 55°F on 24th February and the trays moved weekly to even out differences in the lighting pattern in the store. The temperature in the sprouting store was lowered from 50° - 55°F to 45°F on 27th March and all treatments were transferred to 40°F on 30th March to arrest further sprout development over the period of planting. Temperatures during the storage and sprouting phases and over the period of planting are shown in figure 3 and table 5 of the Appendix.

A split-plot design was used in the field. Seed size was allocated to main plots, date of planting to sub-plots and sprouting to sub sub-plots. There were two replicates. Midrigs between banks of sub-plots were left to permit easy access for field operations at each date of planting. Provision was made in the plot layout for tractor spraying for blight control as in the previous experiment (Section I, Experiment 1). The experiment was conducted in the same field as Experiment 4 and the pre-planting field operations were the same as for Experiment 4, with the exception that very shallow ridges were drawn over the whole experimental area and then the plots for each date of planting were drawn deeper when required. Planting was carried out every two days from 4th April. Data for soil moisture at 9 inches below the top of the ridge, rainfall, soil and air temperature over the planting period are given in table 5 of the Appendix. Ridges were always split to cover the tubers on the day of planting. Weed control was carried out by spraying with linuron (2 lb. per acre A.I.) in 30 gallons of water to the treatments on the following dates.

Planting dates: 1, 2, 3, 4 sprouted, 9th May, 5,6, 7, 8 sprouted, 10th May, 9, 10, 11, 12 sprouted and 1, 2, 3, 4 unsprouted, 11th May, 5, 6, 7, 8 unsprouted and 13, 14 sprouted, 18th May, 9, 10, 11, 12 unsprouted, 24th May, and 13, 14 unsprouted, 26th May.

Preventative blight spraying was carried out on 18th, 28th July and 13th September. All plots were allowed to mature naturally and were harvested on 17th October in dry conditions. Total tuber weight and number were recorded, together with the number and weight in four riddle sizes. Samples of about $\frac{1}{6}$ of the total weight per plot were taken for dry matter determinations.

Plot size was $\frac{1}{276}$ acre divided into an area of $\frac{1}{690}$ acre for final harvest and the rest for 5 samples of 3 plants per sample for growth study. Details of plant arrangement and sampling procedure used were identical to those of Experiments 1 and 2, Section I, except that sampling was staggered to lift each treatment at approximately the same number of days after emergence (Appendix, table 23). As a result statistical estimates of differences between treatments could not be obtained. However, an Analysis of Variance carried out on a sample of three plants at harvest showed a coefficient of variation of 20% which is of the same order as those obtained in Experiments 1 and 2 for a series of variates. At each sample lift, both foliage and tuber fresh and dry weights were recorded. Tubers were graded into the following size groups: 0-25g, 25-50g, 50-100g, 100-150g, 150-200g, 200-300g and >300 g, and number and weight in each grade recorded. Counts were made of mainstems and the total number of stems at ground level. In addition an estimate of the incidence of the disorder 'coiled-sprout' was made (Section I, Experiment 1).

Dates of Sampling

Planting dates	Sample lift 1	2	3	4	5
1- 7 sprouted	12/6/67	20/6/67	5/7/67	20/7/67	14/8/67
8-10 sprouted) 1-4 unsprouted)	16/6/67	29/6/67	12/7/67	27/7/67	17/8/67
11-14 sprouted) 5- 7 unsprouted)	19/6/67	3/7/67	17/7/67	3/8/67	21/8/67
8-14 unsprouted	22/6/67	7/7/67	24/7/67	8/8/67	28/8/67

The date of tuber initiation was taken to occur at the start of rapid bulking, which commenced at about 50 g. fresh weight of tubers per plant. Bulking rates were calculated, assuming that bulking showed a linear relationship with time (figure 26), over the period from sample lift 2 to sample lift 5. Counts of the number of plants emerged per plot and scores for the percentage of green leaf remaining were carried out to estimate the date of 50% emergence and the date of 75% senescence, on 10th, 12th, 14th, 17th, 21st, 24th, 29th May, 1st, 5th, 6th and 13th June for emergence and 7th, 23rd, 28th August, 1st, 7th, 13th, 20th, 27th September and 3rd and 10th October for senescence. Because the course of foliage senescence after the 75% point was erratic this point was used in preference to the 95% stage used in earlier experiments. Although a small amount of tuber growth may have been made after 75% senescence (Hanley <u>et al</u>., 1965; Will, 1966) it was likely to be small, for Radley (1963) showed that in Ulster Torch little tuber growth took place over the first two weeks in September when the leaf area index (L.A.I.) decreased from 2.5 - 3.0 to zero. During the season air and soil temperatures at 9 inches below the top of the ridge and soil water at 3", 9", 1'6" below the top of the ridge over the period of tuber initiation were recorded.

Soil water measurement (tables 55 and 56)

Maximal available water for plant growth was determined as the difference between the soil water content at field capacity and at the permanent wilting point.

So

Available soil water (inches) = (% soil water at field capacity - % soil water at permanent wilting point) x bulk density (weight/volume oven dry soil g./c.c.) x depth of soil in inches.

Actual available soil water content was determined in the same way.

Soil water contents were determined gravimetrically at approximately 3-day intervals from 25th May to 19th July. Soil was taken from the middle of the ridge at 3", 9" and 1'6" depths (lower limit of maximum root concentration) below the top of the ridge from six sites, and placed in airtight containers. The soil was oven-dried at 105°C for 12 hours. Percentage soil water was calculated from the wet and dry weights. Bulk densities were determined at each of these depths on two separate occasions over 9 sites using a corer of

Table 54. - Effect of sprout treatment on percentage dry matter at harvest.

Treatment	% dry matter
1	19.63
2	19.63
3	19.53
4	19.41
5	19.42
6	19.69
7	19.93
8	19.79
S.E.	±0.23

Table 55 - Change in bulk density of the soil with depth below the top of the ridge: weight/volume ratio (g/cc oven-dried soil).

3"	1.179	
9"	1.302	± 0.07
1'6"	1.412	

Table 56 - Soil water determinations.

a) Percentage soil water content determined grammetrically at field capacity (F.C.) and permanent wilting point (P.W.P.).

Depth of soil below the top of the ridge	F.C.	Sample	P.W.P.	Sample	P.W.P.
3"	20.2%	1	9.26%	4	9.61%
9"	21.1%	2	9.82%	5	8.88%
1'6"	21.4%	3	9.47%	6	10.80%

b) Percentage soil water content and available water contents of the soil (A.W.C.).

Date	% water content			% available water			Total A.W.C. in inches per $1\frac{1}{2}$'	Total A.W.C. as % of A.W.C. per $1\frac{1}{2}$' at field capacity	Soil moisture tension at 9" below the top of the ridge cm. Hg.
	3"	9"	1'6"	3"	9"	1'6"			
25 May	17.5	19.4	21.2	7.59	9.69	11.74	2.346	87.47	-
1 June	17.9	20.3	20.7	8.36	10.76	11.16	2.445	91.16	0
13 June	13.4	20.2	21.4	3.86	10.66	11.86	2.358	87.92	4.0
16 June	11.6	19.1	22.1	2.06	9.56	12.56	2.298	85.46	6.0
19 June	9.4	19.0	19.6	0	9.46	10.06	1.918	71.51	19.0
22 June	8.6	18.1	20.1	0	8.56	10.56	1.906	71.07	20.0
28 June	11.6	18.3	20.3	2.06	8.76	10.76	2.018	75.24	18.0
4 July	8.3	16.7	19.7	0	7.16	10.16	1.749	65.21	26.0
10 July	8.8	16.3	18.9	0	6.76	9.36	1.625	60.59	36.0
13 July	9.7	15.9	16.2	0.16	6.36	6.66	1.334	49.74	-
19 July	14.5	18.3	20.5	4.96	8.76	10.96	2.143	79.90	-

10.5 cm. diameter and 5.05 cm. length.

Field capacity (F.C.) was determined gravimetrically by field sampling in October 1967 about 2-3 days after a prolonged period of heavy rain (Veihmeyer and Hendrickson, 1949; Salter, 1967). One sample from each depth over 2 sites was taken.

Permanent wilting point (P.W.P.) was determined by the method of Veihmeyer and Hendrickson (1949) using sunflower seeds. Soil from the 9" depth only was used, 6 sites being sampled. In the calculation of P.W.P., samples 5 and 6 were ignored (table 56). The plant in sample 6 was diseased and in 5 the plant was dead at the time of sampling.

3. Results

3.1. Sprout and stem data

3.1.1. Sprout development at planting time (table 57)

Sprout length in the sprouted treatments increased during storage over the planting period. There was little change in sprout number during this time. At the first few dates of planting in the unsprouted treatment there were few sprouts and most of these were less than 1 mm. in length. With increasing length of storage more buds started to grow with a result that sprout number during the storage period increased. Accompanying this was an increase in sprout length, the sprouts being white from storage without light. However, sprout growth in all the treatments was fairly even; few sprouts

Table 57 - Effect of sprouting on a) sprout number, b) sprouts > 8 mm, c) sprout length and d) the number and length of lateral branches per tuber at the time of planting.

Date of planting	a) Sprout number per tuber: Sprouted	Unsprouted	Mean	b) Number of sprouts > 8 mm per tuber: Sprouted	Unsprouted
1	11.9	3.4	7.6	2.07	0
2	11.8	6.0	8.9	2.07	0
3	10.7	7.5	9.1	2.00	0
4	10.7	7.5	9.1	2.00	0
5	12.0	7.7	9.8	2.43	0
6	11.5	8.3	9.9	1.97	0
7	9.6	9.9	9.7	2.07	0
8	9.4	10.0	9.7	2.07	0
9	11.3	9.3	10.3	2.27	0
10	11.0	10.9	10.9	2.20	0
11	10.2	11.2	10.7	2.33	0.16
12	9.9	11.2	10.6	2.20	0.10
13	10.1	10.6	10.4	2.43	0.50
14	10.6	12.0	11.3	2.36	0.60
Mean	10.8	8.9		2.18	0.10

S.E. body of table (vertical and diagonal comparisons) ±0.687

S.E. body of table (horizontal comparisons) ±0.583

S.E. planting date means ±0.412

S.E. sprouting means ±0.397

Table 57 (contd.)

	c) Sprout length per tuber (mm.)			d) Number of lateral branches		Length of lateral branches (mm.)	
	Sprouted	Un-sprouted	Mean	Sprouted	Un-sprouted	Sprouted	Un-sprouted
1	45.0	4.1	24.6	0.13	0	0.2	0
2	44.5	6.9	25.7	0.27	0	0.4	0
3	43.9	8.5	26.2	0.37	0	0.4	0
4	-	-	-	0.37	0	0	0
5	49.0	9.3	29.1	0	0	0	0
6	42.7	12.2	27.5	0.10	0	0.1	0
7	40.6	14.6	27.6	0.67	0	0.1	0
8	44.8	14.9	29.8	0.30	0	0.4	0
9	50.3	19.5	34.9	0.87	0	1.9	0
10	50.9	22.3	36.6	0.37	0	0.7	0
11	54.4	22.1	38.2	0.13	0	0.4	0
12	50.9	27.6	39.2	0.40	0	0.8	0
13	52.5	31.7	42.1	1.07	0	2.1	0
14	58.9	33.8	46.3	0.63	0	1.3	0
Mean	44.9	16.2					

S.E. body of table (vertical and diagonal comparisons	±4.40
S.E. body of table (horizontal comparisons)	±2.66
S.E. planting date means	±3.58
S.E. sprouting means	±1.88

exceeded 8 mm. and showed no lateral-branch development at planting time.

3.1.2. Stem growth (table 58)

At all dates of planting the unsprouted treatment produced a significantly greater number of mainstems than the sprouted treatment but as a result of the better lateral-branch development, the sprouted treatment produced a significantly greater total number of stems at ground level.

There was a tendency for mainstem numbers to increase with delay in planting of unsprouted seed but not of sprouted seed. For both sprouted and unsprouted seed there was a slight increase in the total number of stems at ground level with delay in planting. This reflected, in unsprouted seed, the increase in mainstems, but, in sprouted seed, the increase was largely due to the greater degree of lateral-branch development on the sprout at planting time. The incidence of 'coiled-sprout' was moderate (table 58), but the incidence of severe coiling (Section I, Experiment 1) was low in sprouted seed. There was virtually no coiling from unsprouted seed. In general, delay in planting led to an increase in the occurrence of 'coiled-sprout', possibly as a result of the increase in sprout length per tuber with delay in planting (Moorby and McGee, 1966).

Table 58 - Effect of sprouting and planting date on the number of mainstems per hill, stem number at ground level per hill and the number of coiled mainstems.

Planting date	Mainstems per hill Sprouted	Unsprouted	Mean	Stem number at ground level per hill Sprouted	Unsprouted	Mean
1	2.00	2.58	2.29	4.18	2.69	3.44
2	2.00	2.42	2.21	4.18	2.46	3.32
3	1.99	2.43	2.21	4.46	2.54	3.50
4	2.06	2.56	2.31	4.96	2.76	3.86
5	2.03	2.42	2.22	4.53	2.53	3.53
6	1.97	2.54	2.26	4.61	2.64	3.63
7	1.93	2.61	2.27	4.38	2.71	3.54
8	2.00	2.54	2.27	4.76	2.85	3.81
9	1.86	2.72	2.29	4.38	2.90	3.64
10	1.96	2.97	2.47	4.32	3.25	3.78
11	2.17	2.90	2.53	4.72	3.08	3.90
12	1.96	2.83	2.40	4.46	2.94	3.70
13	1.96	3.17	2.56	5.26	3.24	4.25
14	20.1	3.22	2.61	5.57	3.32	4.45
Mean	1.99	2.71		4.63	2.85	

S.E. (1) body of table (vertical and diagonal comparisons) ±0.177

S.E. (1) ±0.275

S.E. (2) body of table (horizontal comparisons) ±0.136

S.E. (2) ±0.196

S.E. (3) planting date means ±0.149

S.E. (3) ±0.238

S.E. (4) sprouting means ±0.036

S.E. (4) ±0.052

Table 58 (contd.)

Percentage of mainstems per hill showing symptoms of 'coiled sprout'.

Planting date	Sprouted	Unsprouted
1	35	0
2	23	0
3	45	0
4	42	0
5	39	0
6	37	0
7	43	0
8	51	0
9	49	0
10	57	0
11	44	0
12	51	0
13	53	0
14	54	0

3.2. Field growth

3.2.1. General aspects of growth (tables 59, 60, 61)

The early part of the season was very wet with 6 inches of rain in May. Afterwards, there was an increasing water deficit until the middle of July (Appendix, table 6). Blight was not a problem but there was some soft rotting at harvest.

With delay in planting in both the sprouted and unsprouted seed, emergence and apparent tuber initiation was later. Early planting of the sprouted seed resulted in slow rates of emergence but becoming more rapid with delay in planting. There was a similar but not so marked effect for the unsprouted seed, though the rate of emergence from the time the first plant emerged was generally higher than in the sprouted treatment. Days from planting to emergence (P), and planting to tuber initiation (T) progressively declined with delay in planting but the rate of decline in the unsprouted treatment was twice that in the sprouted treatment. This was possibly due, in the latter, to the improvement in the environmental conditions with delay in planting but in the unsprouted treatment, the effect of the greater degree of sprout development with delay in planting would have had an additional effect. As a result, the advantage in the time of emergence and apparent tuber initiation of the sprouted treatments compared with the unsprouted treatments, which was found at the early dates of planting, declined with delay in planting (table 60).

Table 59 - Effect of sprouting and planting date on dates of 50% emergence (E), time of apparent tuber initiation (I) and senescence(S).

Planting date	Sprouted			Unsprouted		
	E	I	S	E	I	S
1	19/5	18/6	29/9	31/5	1/7	1/10
2	22/5	22/6	26/9	31/5	2/7	29/9
3	23/5	21/6	29/9	31/5	2/7	30/9
4	24/5	21/6	24/9	31/5	2/7	27/9
5	24/5	21/6	25/9	31/5	1/7	28/9
6	26/5	22/6	26/9	31/5	2/7	30/9
7	27/5	23/6	28/9	3/6	3/7	30/9
8	30/5	26/6	28/9	3/6	5/7	30/9
9	30/5	26/6	27/9	6/6	5/7	1/10
10	1/6	26/6	28/9	6/6	6/7	30/9
11	3/6	26/6	28/9	6/6	6/7	30/9
12	3/6	30/6	29/9	8/6	6/7	1/10
13	7/6	3/7	27/9	10/6	7/7	1/10
14	7/6	5/7	28/9	10/6	8/7	1/10

Table 60 - Advantage of sprouted over unsprouted tubers in time to 50% emergence (E), apparent tuber initiation (I) and 75% senescence (S).

	Days		
Planting date	E	I	S
1	12	13	2
2	9	10	3
3	10	11	1
4	9	11	3
5	7	11	3
6	5	9	4
7	6	10	2
8	4	9	2
9	6	9	4
10	5	8	2
11	4	8	2
12	3	7	2
13	3	4	4
14	3	3	3

Table 61 - Days from planting to emergence (P) and planting to tuber initiation (T); days from emergence to tuber initiation (E) and days from tuber initiation to senescence(S).

Date of planting	Sprouted				Unsprouted			
	P	T	E	S	P	T	E	S
1	46	77	31	104	58	90	32	92
2	47	79	32	97	56	89	33	89
3	44	74	30	101	54	87	33	90
4	43	72	29	96	52	85	33	87
5	43	72	29	97	50	82	32	89
6	43	71	28	97	48	81	33	90
7	42	70	28	98	48	78	30	89
8	42	69	27	95	46	74	28	87
9	41	68	27	94	47	72	25	88
10	41	66	25	95	46	70	24	86
11	39	62	23	95	43	67	24	86
12	39	66	27	92	44	65	21	87
13	40	66	26	86	43	65	22	86
14	37	65	28	85	40	63	23	85

In both the sprouted and unsprouted treatments early planting resulted in a longer growing season (measured from 50% emergence to 75% senescence). However, in the unsprouted treatment there was no effect of planting date on the length of the bulking period (measured from the time of apparent tuber initiation to 75% senescence). Delay in planting of the sprouted lots resulted in a shorter period of bulking.

3.2.2. Tuber yields and tuber numbers (tables 62, 63, 64, 65, 66, 67)

On average there was no significant difference in total yield between the sprouted and unsprouted treatments though the sprouted treatment produced a significantly greater number of tubers (14%), but there was a significant interaction between sprouting and planting date.

At the early dates of planting, up to planting date 5, there was a decline in yield for both sprouted seed (0.7 tons per acre per week) and unsprouted seed (0.4 tons per acre per week). However, in sprouted seed there was little change in the number of tubers over this period but in unsprouted seed, tuber numbers showed a steady increase to planting date 5. On average over this period sprouted seed produced a $7\frac{1}{2}$% greater yield and 22% more tubers than unsprouted seed. After planting date 5, the level of yield and tuber number remained similar in both sprouted and unsprouted seed due largely to the slight increase in yield and the larger increase in tuber

Table 62 - Effect of sprouting and planting date on tuber yields (tons per acre).

Planting date	Yield of ware tubers ($> 2\frac{1}{4}$")			Yield of large seed tubers ($1\frac{3}{4}$" - $2\frac{1}{4}$")		
	Sprouted	Unsprouted	Mean	Sprouted	Unsprouted	Mean
1	13.36	12.27	12.82	3.50	3.10	3.30
2	14.85	14.19	14.52	4.22	2.97	3.59
3	14.08	12.64	13.36	3.36	3.41	3.38
4	14.51	13.75	14.13	3.61	3.46	3.54
5	12.59	12.82	12.71	3.42	2.98	3.20
6	12.10	11.19	11.65	3.56	3.18	3.37
7	11.94	12.44	12.19	3.18	3.54	3.36
8	13.20	11.64	12.42	3.36	3.36	3.36
9	11.97	13.29	12.63	3.49	3.83	3.66
10	14.25	12.18	13.22	3.67	3.16	3.41
11	12.44	12.40	12.42	2.98	3.77	3.38
12	10.98	12.21	11.59	3.31	4.37	3.84
13	11.51	12.27	11.89	4.22	4.05	4.13
14	11.72	12.36	12.04	3.61	4.54	4.08
Mean	12.82	12.55		3.53	3.55	

S.E. (1) body of table (vertical and diagonal comparisons)	±0.679	S.E. (1)	±0.265
S.E. (2) body of table (diagonal comparisons)	±0.667	S.E. (2)	±0.268
S.E. (3) planting date means	±0.489	S.E. (3)	±0.185
S.E. (4) sprouting means	±0.178	S.E. (4)	±0.072

Table 62 (contd.)

Planting date	Yield of small seed tubers ($1\frac{1}{4}$" - $1\frac{3}{4}$") Sprouted	Unsprouted	Mean	Yield of chats (<$1\frac{1}{4}$") Sprouted	Unsprouted	Mean
1	0.71	0.59	0.65	0.22	0.15	0.19
2	0.75	0.66	0.70	0.27	0.28	0.28
3	0.73	0.58	0.66	0.22	0.22	0.22
4	0.81	0.69	0.75	0.31	0.19	0.25
5	0.87	0.53	0.70	0.36	0.13	0.24
6	0.58	0.71	0.64	0.28	0.27	0.27
7	0.68	0.63	0.66	0.22	0.18	0.20
8	0.66	0.72	0.69	0.27	0.31	0.29
9	0.66	0.71	0.68	0.31	0.21	0.26
10	0.68	0.66	0.67	0.32	0.26	0.29
11	0.75	0.76	0.75	0.31	0.18	0.24
12	0.69	0.77	0.73	0.23	0.28	0.26
13	0.93	0.72	0.82	0.39	0.28	0.33
14	0.94	0.78	0.86	0.40	0.28	0.34
Mean	0.75	0.68		0.29	0.23	

S.E. (1) ±0.080	S.E. (1) ±0.044
S.E. (2) ±0.079	S.E. (2) ±0.047
S.E. (3) ±0.057	S.E. (3) ±0.029
S.E. (4) ±0.021	S.E. (4) ±0.013

Table 62 (contd.)

Planting date	Yield of seed (1¼" - 2¼")			Total yield of tubers		
	Sprouted	Unsprouted	Mean	Sprouted	Unsprouted	Mean
1	4.21	3.69	3.95	17.79	16.12	16.95
2	4.96	3.63	4.30	20.09	18.10	19.09
3	4.09	3.99	4.04	18.39	16.85	17.62
4	4.42	4.15	4.29	19.24	18.10	18.67
5	4.30	3.51	3.90	17.25	16.46	16.85
6	4.14	3.88	4.01	16.53	15.34	15.93
7	3.86	4.17	4.01	16.01	16.78	16.40
8	4.01	4.08	4.04	17.48	16.03	16.75
9	4.14	4.54	4.34	16.42	18.03	17.23
10	4.35	3.82	4.08	18.92	16.26	17.59
11	3.73	4.53	4.13	16.48	17.11	16.79
12	4.00	5.14	4.57	15.21	17.63	16.42
13	5.14	4.77	4.96	17.04	17.32	17.18
14	4.55	5.32	4.94	16.67	17.97	17.32
Mean	4.28	4.23		17.39	17.01	

S.E. (1) ±0.296		S.E. (1) ±0.716
S.E. (2) ±0.296		S.E. (2) ±0.673
S.E. (3) ±0.210		S.E. (3) ±0.534
S.E. (4) ±0.079		S.E. (4) ±0.180

Table 63 - Effect of planting date on the advantage of sprouted seed over unsprouted seed in tuber yield (tons per acre).

Planting date	Ware ($>2\frac{1}{4}$")	Seed ($1\frac{1}{4}$"-$2\frac{1}{4}$")	Total tubers
1	1.09	0.52	1.67
2	0.66	1.33	1.99
3	1.44	0.10	1.54
4	0.76	0.27	1.14
5	-0.23	0.79	0.79
6	0.91	0.26	1.19
7	-0.50	-0.31	-0.77
8	1.56	-0.07	1.45
9	-1.32	-0.40	-1.61
10	2.07	0.53	2.66
11	0.04	-0.80	-0.63
12	-1.23	-1.14	-2.42
13	-0.76	0.37	-0.28
14	-0.64	-0.77	-1.30

Table 64 - Effect of sprouting and planting date on tuber numbers (thousands per acre).

Planting date	Number of ware tubers ($>2\frac{1}{4}"$) Sprouted	Unsprouted	Mean	Number of large seed tubers ($1\frac{3}{4}" - 2\frac{1}{4}"$) Sprouted	Unsprouted	Mean
1	44.5	40.9	42.7	31.3	25.6	28.5
2	50.9	42.9	46.9	36.4	23.7	30.1
3	48.9	41.1	45.0	31.5	28.6	30.0
4	49.4	48.4	48.9	31.6	29.8	30.7
5	44.0	43.7	43.8	31.1	24.2	27.7
6	39.4	36.8	38.1	31.7	27.8	29.7
7	40.9	41.3	41.1	27.9	28.3	28.1
8	42.5	39.3	40.9	28.6	29.8	29.2
9	39.2	44.7	41.9	29.8	31.8	30.8
10	46.0	43.3	44.7	30.5	27.2	28.9
11	43.2	44.0	43.6	27.2	31.3	29.3
12	37.8	43.1	40.4	28.2	38.5	33.4
13	38.5	44.5	41.5	35.1	37.8	36.5
14	39.3	42.9	41.1	31.2	38.7	35.0
Mean	43.2	42.6		30.9	30.2	30.6

S.E. (1) body of table (vertical and diagonal comparisons)	±2.37	S.E. (1) ±2.24
S.E. (2) body of table (horizontal comparisons)	±2.44	S.E. (2) ±2.29
S.E. (3) planting date means	±1.63	S.E. (3) ±1.56
S.E. (4) sprouting means	±0.65	S.E. (4) ±0.61

Table 64 (contd.)

Planting date	Number of small seed tubers ($1\frac{1}{4}$" - $1\frac{3}{4}$") Sprouted	Unsprouted	Mean	Number of chats (< $1\frac{1}{4}$") Sprouted	Unsprouted	Mean
1	13.6	9.3	11.5	14.9	9.8	12.3
2	13.7	9.9	11.8	15.3	15.8	15.6
3	13.5	9.6	11.5	14.8	12.3	13.5
4	13.7	10.9	12.3	19.2	11.3	15.3
5	14.4	8.5	11.5	22.4	9.7	16.0
6	9.8	11.4	10.6	18.4	15.1	16.8
7	11.8	10.1	10.9	10.8	12.1	11.5
8	11.9	12.1	12.0	17.2	16.0	16.6
9	12.6	12.1	12.3	19.5	13.3	16.4
10	10.4	9.7	10.0	16.9	16.9	16.9
11	13.5	11.9	12.7	19.1	11.4	15.3
12	11.3	13.5	12.4	14.1	16.5	15.3
13	16.7	11.8	14.2	20.5	15.2	17.9
14	14.9	13.0	13.9	19.7	14.5	17.1
Mean	13.0	11.0		17.3	13.6	

S.E. (1) ±1.48
S.E. (2) ±1.38
S.E. (3) ±1.12
S.E. (4) ±0.37

S.E. (1) ±2.42
S.E. (2) ±2.66
S.E. (3) ±2.66
S.E. (4) ±0.71

Table 64 (contd.)

Planting date	Total number of seed tubers ($1\frac{1}{4}$" - $2\frac{1}{4}$")			Total number of tubers		
	Sprouted	Unsprouted	Mean	Sprouted	Unsprouted	Mean
1	44.9	34.9	39.9	104.3	85.6	95.0
2	50.1	33.6	41.9	116.4	92.3	104.3
3	44.9	38.1	41.5	108.6	91.6	100.1
4	45.3	40.8	43.0	114.0	100.5	107.2
5	45.5	32.7	39.1	111.9	86.1	99.0
6	41.5	39.2	40.3	99.3	91.0	95.2
7	39.6	38.5	39.1	91.4	91.8	91.6
8	40.4	41.9	41.2	100.1	97.3	98.7
9	42.4	43.9	43.2	101.1	101.9	101.5
10	40.9	36.9	38.9	103.8	97.1	100.5
11	40.7	43.2	41.9	103.0	98.6	100.8
12	39.5	52.0	45.7	91.4	111.6	101.5
13	51.9	49.6	50.7	110.9	109.2	110.1
14	46.1	51.7	48.9	105.1	109.1	107.1
Mean	43.8	41.2		104.4	97.4	

S.E. (1)	±3.02	S.E. (1)	±4.99
S.E. (2)	±2.87	S.E. (2)	±4.76
S.E. (3)	±2.24	S.E. (3)	±3.68
S.E. (4)	±0.77	S.E. (4)	±1.27

Table 65 - Effect of planting date on the advantage of sprouted seed over unsprouted seed on tuber number (thousands per acre).

Planting date	Ware ($>2\frac{1}{4}$")	Total seed ($1\frac{1}{4}$" - $2\frac{1}{4}$")	Total tubers
1	3.6	10.0	18.7
2	8.0	16.5	24.1
3	7.8	6.8	17.0
4	1.0	4.5	13.5
5	0.3	12.8	25.8
6	2.6	2.3	8.3
7	-0.4	1.1	- 0.4
8	3.2	- 1.5	2.8
9	-5.5	- 1.5	- 0.8
10	2.7	4.0	6.7
11	-0.8	- 2.5	4.4
12	-5.3	-12.5	-20.2
13	-6.0	2.3	1.7
14	-3.6	- 5.6	- 4.0

Table 66 - Effect of sprouting and planting date on tuber dry matter yield at harvest (tons per acre).

Planting date	Sprouted	Unsprouted	Mean
1	3.61	3.12	3.36
2	4.15	3.63	3.89
3	3.80	3.32	3.56
4	4.08	3.67	3.87
5	3.40	3.40	3.40
6	3.26	2.98	3.12
7	3.17	3.24	3.21
8	3.36	3.08	3.22
9	3.25	3.49	3.37
10	3.67	3.21	3.44
11	3.30	3.40	3.35
12	3.02	3.37	3.20
13	3.28	3.31	3.30
14	3.24	3.44	3.34
Mean	3.47	3.33	

S.E. body of table (vertical and diagonal comparisons)	±0.148
S.E. body of table (horizontal comparisons)	±0.142
S.E. planting date means	±0.109
S.E. sprouting means	±0.038

Table 67 - Effect of sprouting and planting date on percentage tuber dry matter at harvest.

Planting date	Sprouted	Unsprouted	Mean
1	20.38	19.35	19.87
2	20.65	20.11	20.38
3	20.66	19.64	20.15
4	21.24	20.32	20.78
5	19.73	20.63	20.18
6	19.78	19.49	19.64
7	19.91	19.23	19.57
8	19.30	19.22	19.26
9	19.84	19.38	19.61
10	19.44	19.77	19.60
11	20.11	19.89	20.00
12	19.78	19.09	19.43
13	19.25	19.25	19.25
14	19.42	19.11	19.27
Mean	19.97	19.61	

S.E. body of table (vertical and diagonal comparisons) ±0.463

S.E. body of table (horizontal comparisons) ±0.475

S.E. planting date means ±0.319

S.E. sprouting means ±0.127

number in the unsprouted tubers with further delay in planting.

There was a close relationship between tuber yield and number among planting dates in both sprouted and unsprouted treatments, an increase in tuber number being associated with an increase in yield ($r = 0.78$ **, d.f. 12 for sprouted seed and $r = 0.58$ *, d.f. 12 for unsprouted seed). Further details are shown in table 68.

For both sprouted and unsprouted seed high yields of ware were obtained where the total yield was high and tuber number low. High yields of seed were not so dependent on high total yield but more so on a high tuber number. For the early dates of planting, sprouted seed tended to produce a greater weight of ware and seed tubers than unsprouted seed, as a result of a greater yield and number of tubers. For the later dates of planting, this trend was reversed due to the higher level of yield and tuber number in unsprouted seed.

The percentage dry matter content of the tubers was significantly higher, by 0.36 units per cent on average, in the sprouted than in the unsprouted treatments (table 67). Although there was a slight decline in percentage tuber dry matter content in both the sprouted and unsprouted treatments with delay in planting, the pattern of dry matter yield followed fresh weight yield closely.

3.2.3. Relationships between tuber number, stem number and other variables (tables 68, 69)

Correlations between tuber number and mainstem number and tuber number and total stem number at ground level were calculated among planting dates for both the sprouted and unsprouted treatments. In unsprouted seed, an increase in both mainstems and total stems was associated with an increase in tuber number, the linear relationship accounting for 55% and 58% of the total variance in tuber number respectively. For sprouted seed large differences in tuber number occurred irrespective of differences in the number of mainstems or the total number of stems at ground level.

Over most of the period of tuber formation in sprouted seed there was a progressive reduction in the available soil water content from about 70% of total available water at planting date 1 to about 60% of total available water at planting date 12. The deficit was relieved by rainfall in the second week of July and soil moisture contents at tuber formation in planting dates 13 and 14 were about 80% of total available water. In the unsprouted treatment there was a gradual rise in the available soil water content at the time of tuber formation from about 50% available soil water in planting date 1 to 80% available soil water in planting date 14.

The production of tubers followed this pattern of fluctuation in soil water content fairly closely. Since yield and tuber number were related and in the unsprouted treatment, tuber number increased with an increase in stem number, multiple regression analysis was used to relate tuber number to the available soil water content, taking into account the

Table 68 - Relationships between total tuber number (10^3/acre) (Y) and

a) mainstems per hill (X_1),

b) the total number of stems per hill (X_2),

c) tuber yield (tons per acre) (X_3) and

d) available soil water content 12 days after apparent tuber initiation (inches/1.5 feet) (X_4) of the form $Y = a + bX$.

e) Tuber yield (tons/acre) (X_3) and available soil water content 12 days after apparent tuber initiation (inches/1.5 feet) (X_4).

f) Available soil water content 12 days after apparent tuber initiation (inches/1.5 feet) (X_4) and mainstems per hill (X_1).

g) Mainstems per hill (X_1) and tuber yield (tons per acre) (X_3).

h) Tuber yield (tons per acre) (X_3), available soil water content 12 days after apparent tuber initiation (inches/1.5 feet) (X_4) and mainstems per hill (X_1), of the form $Y = \beta_0 + \beta_1 X' + \beta_2 X'' \ldots\ldots + \beta_n X^n$.

Sprouted

	Variate		b	S.E. b	t	% variance removed	F-test overall significance of regression
a)	Y						
	X_1	b	37.00	$\pm$ 29.6	1.25	11.5%	
		a	30.67				

Table 68 (contd.)

Sprouted

	Variate		b	S.E. b	t	% variance removed	F-test overall significance of regression
b)	Y						
	X_2	b	0.33	± 5.43	N.S.	1%	
		a	102.84				
c)	Y						
	X_3	b	4.33	± 1.01	4.29^{**}	60.5%	
		a	29.10				
d)	Y						
	X_4	b	23.96	±23.28	1.03	9%	
		a	62.8				
e)	Y						
	X_3	b_1	3.43	± 0.94	3.65^{**}		
	X_4	b_2	13.64	±10.15	1.34	63%	13.61^{**}
		b_0	20.85	±16.59			
f)	Y						
	X_4	b_1	30.66	±11.67	2.63^{*}		
	X_1	b_2	17.23	±18.26	0.94	35.8%	4.46 N.S.
		b_0	16.90	±38.30			
g)	Y						
	X_1	b_1	17.92	±13.79	1.30		
	X_3	b_2	3.95	± 0.82	4.84^{**}	62.7%	13.47^{**}
		b_0	- 0.78	±29.4			
h)	Y						
	X_3	b_1	3.39	± 0.93	3.65^{**}		
	X_4	b_2	12.07	±10.15	1.19	65.95%	9.68^{*}
	X_1	b_3	15.71	±13.7	1.14		
		b_0	- 7.23	±29.55			

Table 68 (contd.)

	Variate		b	S.E. b	t	% variance removed	F-test overall significance of regression
				Unsprouted			
a)	Y						
	X_1	b	23.75	± 5.98	3.97^{**}	58.5%	
		a	33.12				
b)	Y						
	X_2	b	21.92	± 5.68	3.85^{**}	55.3%	
		a	34.92				
c)	Y						
	X_3	b	5.44	± 2.21	2.47^{*}	33.1%	
		a	4.92				
d)	Y						
	X_4	b	23.50	± 4.26	5.51^{**}	71.7%	
		a	56.9				
e)	Y						
	X_3	b_1	3.50	± 1.20	2.90^{*}		
	X_4	b_2	20.57	± 3.61	5.70^{**}	83.21%	27.25^{**}
		b_0	2.32	±19.74			
f)	Y						
	X_4	b_1	21.31	±10.10	2.11		
	X_1	b_2	2.75	±11.17	0.25	70.53%	13.16^{**}
		b_0	53.21	±16.78			
g)	Y						
	X_1	b_1	20.34	± 5.01	4.06^{**}		
	X_3	b_2	3.76	± 1.51	2.48^{*}	73.46%	15.22^{**}
		b_0	-21.6	±25.66			

Table 68 (contd.)

Unsprouted

Variate	b	S.E. b	t	% variance removed	F-test overall significance of regression
h) Y					
X_3 b_1	3.49	± 1.27	2.76*		
X_4 b_2	19.39	± 8.01	2.42*	83.26%	16.57**
X_1 b_3	1.48	± 8.84	0.17		
b_0	0.54				

Table 69 - Environmental and growth parameters at the time maximum tuber numbers were formed in the sprouted and unsprouted treatments and at other stages of growth.

Sprouted	Available soil water content inches/1.5' 12 days after apparent tuber initiation	Bulk of foliage gm. dry weight per plant at tuber initiation (S)	Maximum foliage dry weight gm.
1	1.92	24.0	89.6
2	1.75	27.7	79.8
3	1.79	23.0	99.5
4	1.79	27.5	100.6
5	1.79	26.5	87.3
6	1.75	28.0	110.0
7	1.73	28.3	89.0
8	1.67	31.3	99.4
9	1.67	32.0	92.5
10	1.67	31.0	97.6
11	1.67	30.3	88.4
12	1.63	31.7	91.7
13	1.60	35.4	112.8
14	1.86	40.0	101.9

Table 69 (contd.)

Unsprouted	Available soil water content inches/1.5' 12 days after apparent tuber initiation	Bulk of foliage gm. dry weight per plant at tuber initiation (S)	Maximum foliage dry weight gm.
1	1.33	33.5	93.0
2	1.47	39.5	111.6
3	1.47	36.5	117.0
4	1.47	37.0	90.5
5	1.33	33.0	100.7
6	1.47	32.3	106.7
7	1.60	37.6	119.6
8	1.86	45.7	127.3
9	1.86	40.0	109.4
10	2.00	43.0	99.0
11	2.00	41.0	107.0
12	2.00	36.5	100.9
13	2.13	36.4	119.4
14	2.13	37.5	107.2

effects of differences in yield and mainstem number. Air temperatures over this period showed little variation in comparison to the changes in soil water and so were not included in the analysis. The available soil water content 12 days after the time of apparent tuber formation was taken as an index of available soil water since this represented the pattern of water deficit over the period of tuber formation and also coincided with the time maximum tuber numbers were formed. The analysis was calculated for sprouted and unsprouted seed separately using the values for total tuber number and weight, and mainstem number averaged over replicate and seed size for each planting date. Soil water contents 12 days after apparent tuber initiation were obtained by interpolating the values from a curve of soil water with time. The results of the analysis are presented in table 68.

For sprouted tubers differences in tuber number appeared to be more closely related to differences in yield level than to changes in soil water content but in the unsprouted tubers there was a small effect of water content on tuber number, an increase in tuber number being associated with an increase in soil water content.

Other aspects of these results will be considered in the discussion.

3.3. Growth analysis

Complete tables of results for tuber number, tuber fresh weight and dry weight, foliage dry weight and total dry weight at each sample lift are presented in tables 17, 18, 19, 20, 21 and 22 of the Appendix. The results from the individual plantings, 1-4, 5-7, 8-10, 11-16, were grouped and the mean values of these 4 groups presented graphically.

3.3.1. The development of tuber number (figure 25)

There was considerable variation in the development of tuber number among planting dates. Maximum tuber numbers were formed over a period of 2-3 weeks from the start of stolon swelling in the early planted treatments for both sprouted and unsprouted seed, but in the later plantings, maximum tuber numbers were formed in a period of about $1\frac{1}{2}$ - 2 weeks. It appeared that there was little difference between planting dates for either sprouted or unsprouted seed in the number of tubers formed, with the possible exception of planting dates 5-7 in sprouted seed, which produced fewer tubers. For unsprouted seed, early planting led to a greater rate of loss of tubers than late planting but for sprouted seed the very early and very late dates of planting showed a slower rate of loss of tubers than the middle dates of planting.

3.3.2. The development of tuber yield (figure 26)

The progress of tuber fresh weight with time is shown in figure 26 and bulking rates are presented in table 70.

Unsprouted seed showed on average a higher rate of bulking than sprouted seed. There was little difference in bulking

Table 70 - Effect of planting date and sprouting on tuber bulking rates (tons per acre per week).

Planting date	Sprouted	Unsprouted	Mean
1	2.12	2.15	2.14
2	2.04	2.20	2.12
3	2.17	2.09	2.13
4	2.25	1.74	1.99
5	1.88	2.30	2.09
6	1.78	2.12	1.95
7	1.98	2.44	2.21
8	2.10	2.89	2.49
9	1.97	2.63	2.30
10	2.17	2.11	2.14
11	2.24	2.44	2.34
12	2.31	2.45	2.38
13	2.44	2.59	2.52
14	2.16	2.42	2.29
Mean	2.12	2.33	

S.E. body of table (vertical and diagonal comparisons) ±0.147

S.E. body of table (horizontal comparisons) ±0.148

S.E. planting date means ±0.103

S.E. sprouting means ±0.040

Figure 25 Effect of time of planting in tubers sprouted before planting time or unsprouted at planting time on the change in tuber number with time.

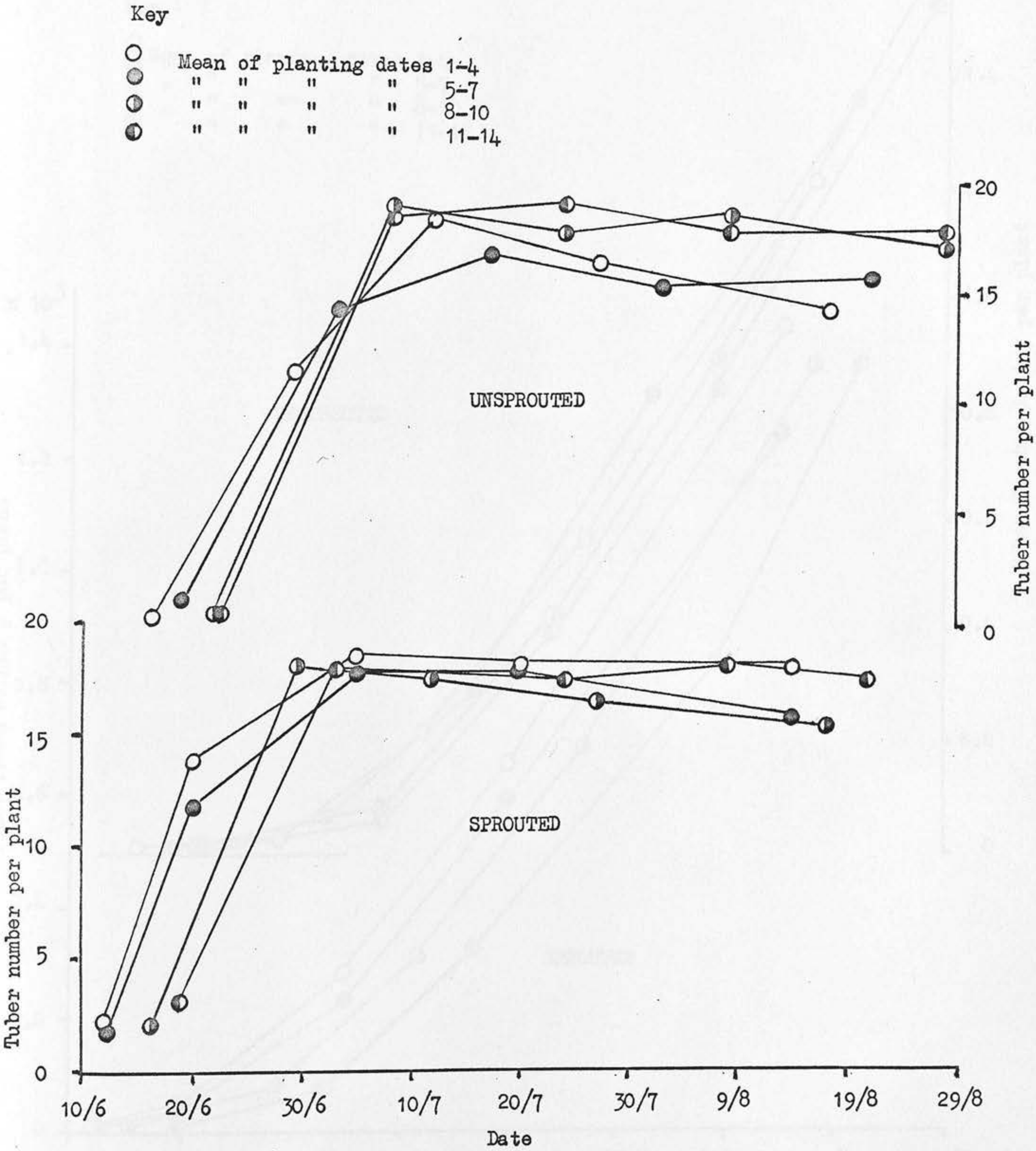


Figure 26 Effect of time of planting in tubers sprouted before planting or unsprouted at planting time on the change in tuber fresh weight with time.

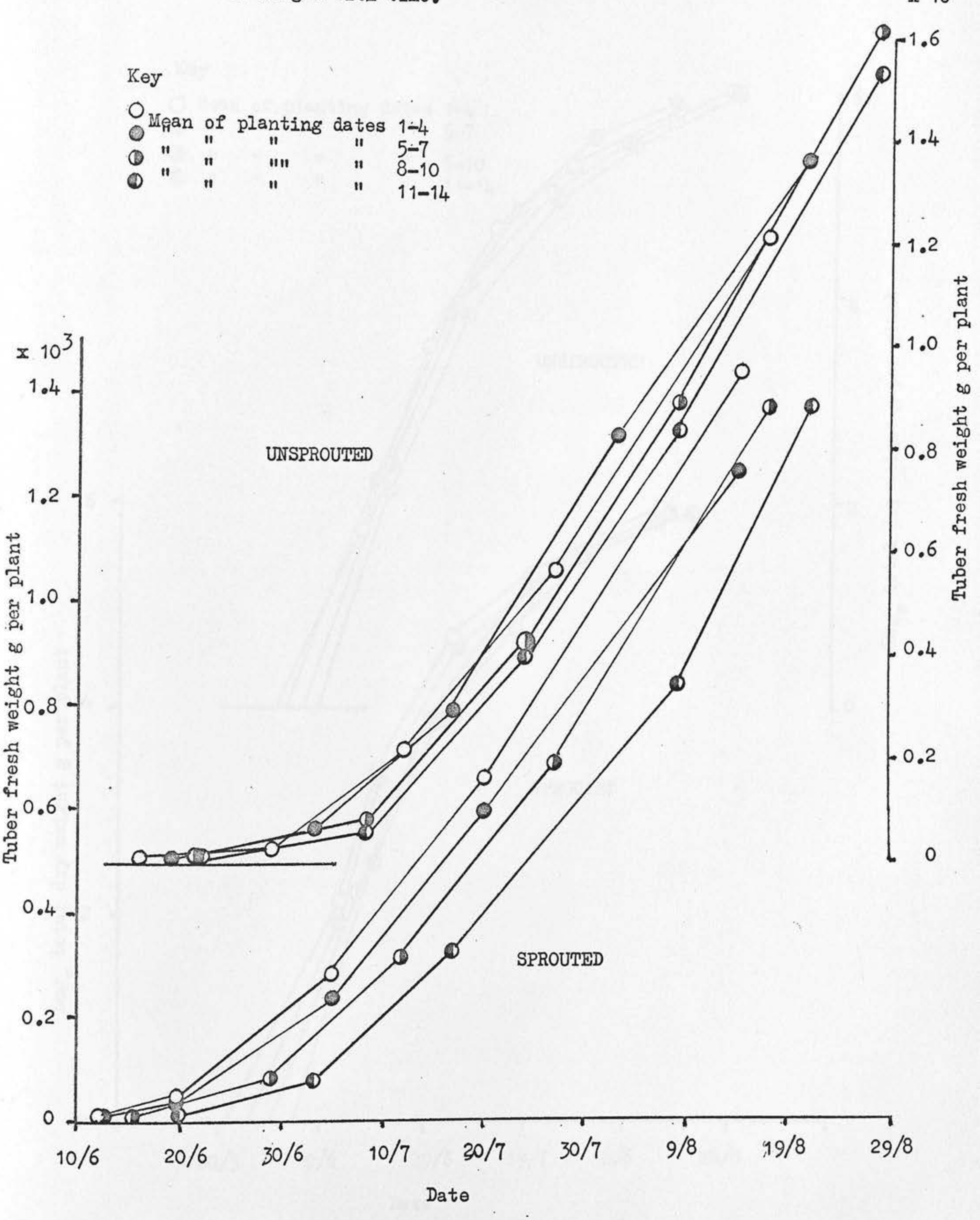


Figure 27 Effect of time of planting in tubers sprouted before planting or unsprouted at planting time on the change in $\log_e$ total dry weight with time.

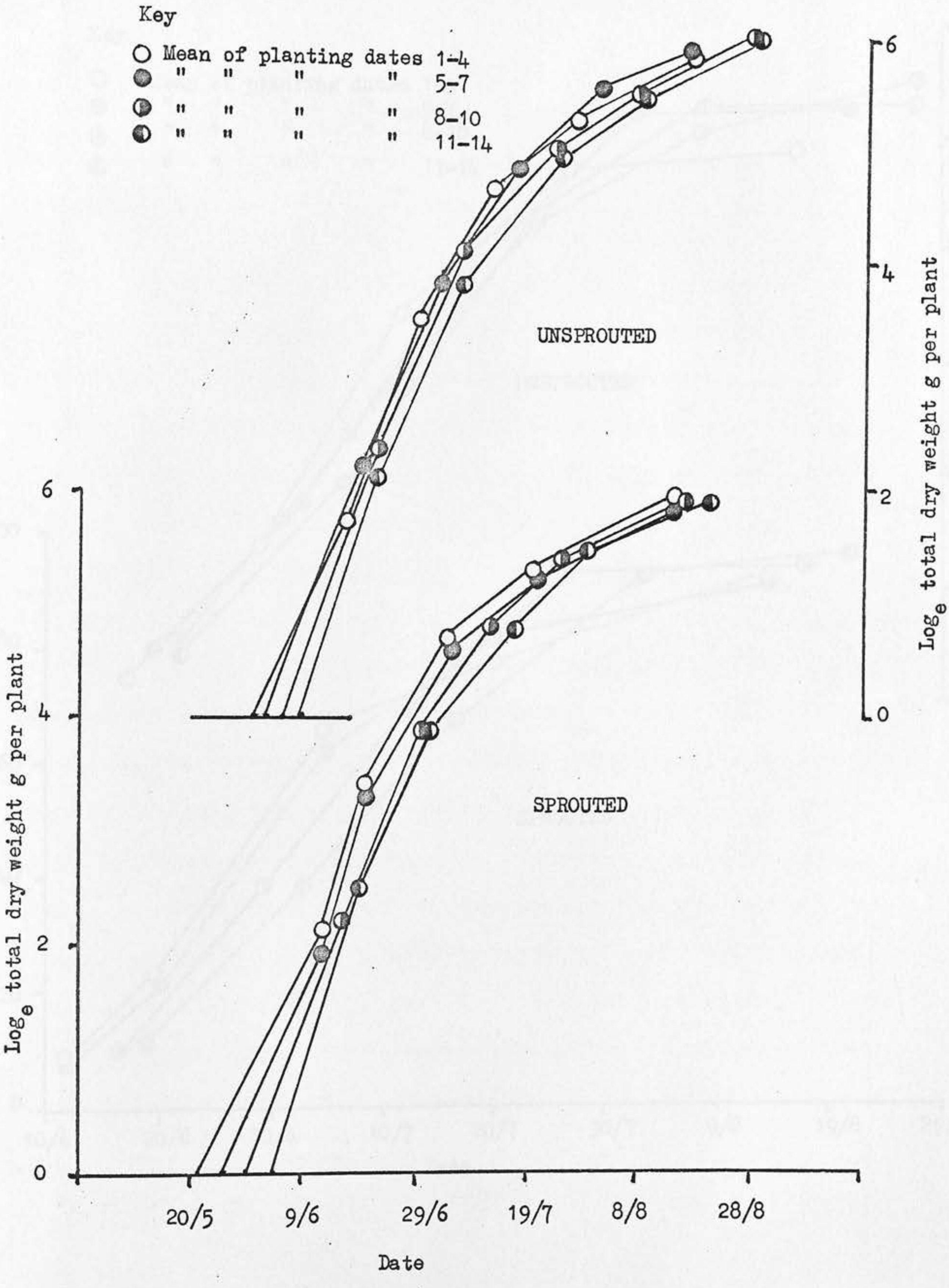
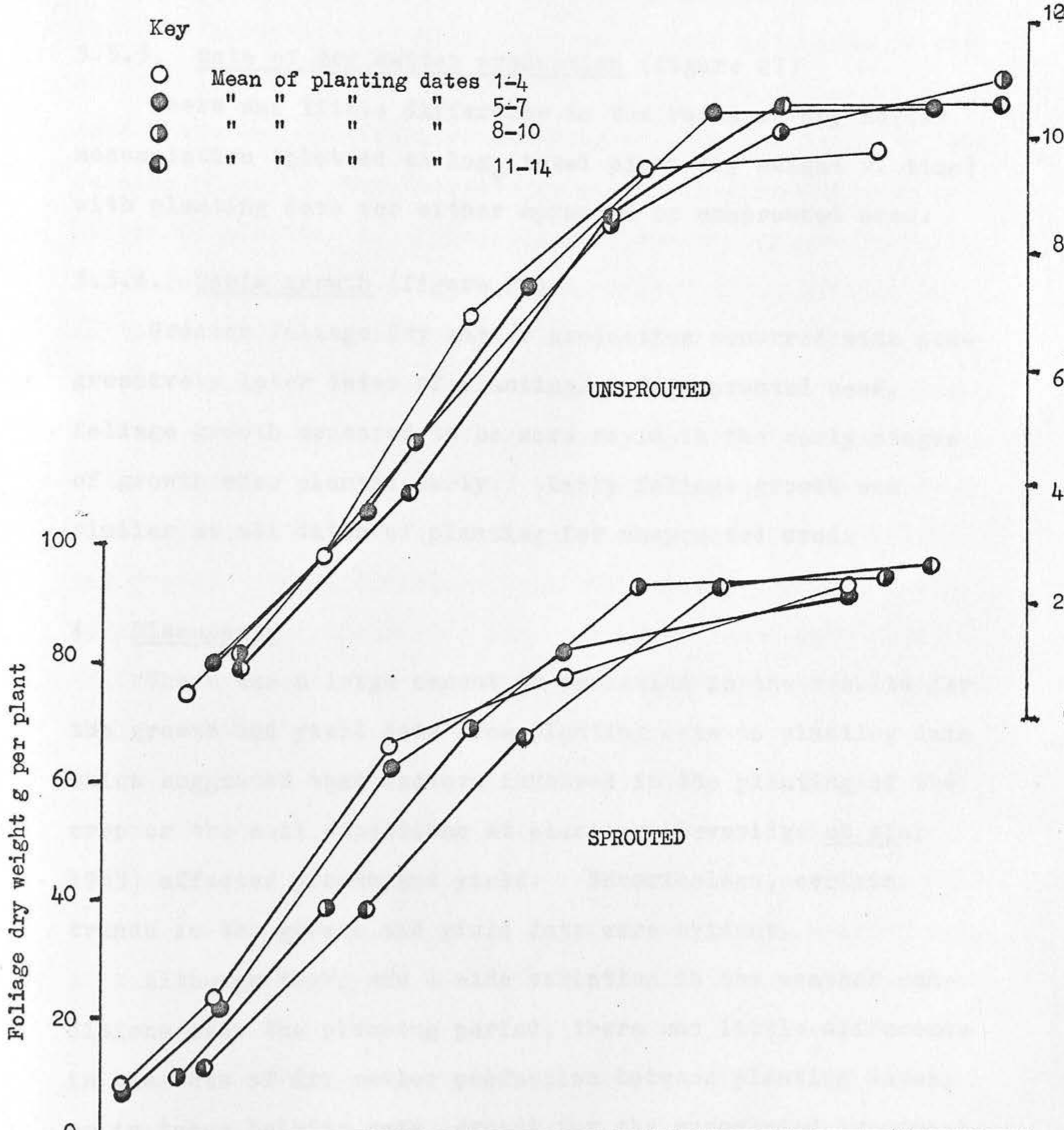


Figure 28 Effect of time of planting in tubers sprouted before planting or unsprouted at planting time on the change in foliage dry weight with time.



rate amongst the planting dates for sprouted seed but with delay in planting of unsprouted seed, there was a general rise in bulking rate.

3.3.3. Rate of dry matter production (figure 27)

There was little difference in the rates of dry matter accumulation (plotted as $\log_e$ total plant dry weight v. time) with planting date for either sprouted or unsprouted seed.

3.3.4. Haulm growth (figure 28)

Greater foliage dry matter production occurred with progressively later dates of planting. For sprouted seed, foliage growth appeared to be more rapid in the early stages of growth when planted early. Early foliage growth was similar at all dates of planting for unsprouted seed.

4. Discussion

There was a large amount of variation in the results for the growth and yield data from planting date to planting date which suggested that factors involved in the planting of the crop or the soil conditions at planting (Beveridge et al., 1965) affected growth and yield. Nevertheless, certain trends in the growth and yield data were evident.

Although there was a wide variation in the weather conditions over the planting period, there was little difference in the rate of dry matter production between planting dates, or in tuber bulking rate, except for the unsprouted treatment, where there was a slight rise in bulking rate with delay in planting. Differences in yield among planting dates were therefore more closely related to differences in the length of the bulking period for sprouted seed but the relationship was not significant (r = 0.36 N.S., d.f. 12). For unsprouted seed there was no effect of planting date on the length of the bulking period. The increase in sprout development over the period of planting in unsprouted seed was partly responsible for a faster rate of emergence and earlier tuber initiation. In this respect the difference in the effect of planting date on the length of the bulking period on sprouted and unsprouted seed is confounded with factors operating during storage. Although there was a slight rise in bulking rate with delay in planting there was little relationship between bulking rate and yield. The differences in yield between sprouted and unsprouted seed with planting date are at variance with the findings of other planting date experiments (North of Scotland College of Agriculture, 1937, 1939; Rothamsted, 1950; Baldwin, 1964; High Mowthorpe E.H.F., 1959, 1962, 1963) where sprouted seed had a greater advantage over unsprouted seed with delay in planting. However, there was a good relationship between these differences in yield and the number of days advantage in the length of the bulking period (r = 0.706 * *, d.f. 12).

An interesting feature was the close positive correlation between total tuber number and total yield. Similar results have been reported from other experiments, for example, seed size and spacing (Taha, 1961); planting date (Broadbent et al., 1957; Bremner and Radley, 1966); irrigation (Llewellyn, 1967); origin and maturity of seed tubers (Goodwin, 1964). In the experiments of Goodwin (1964), an increase in the rate of bulking was associated with an increase in tuber number. In this experiment and Bremner and Taha's (1966) there was little relationship between tuber numbers and bulking rate ($r = 0.132$ N.S., d.f. 12 for sprouted seed and $r = 0.367$ N.S., d.f. 12 for unsprouted seed. Bremner and Taha (1966) suggested that, since more tubers were initiated than survived, as was the case in this experiment, the availability of carbohydrate rather than the ability to utilise it determined the bulking rate. In support of this Bremner and Radley (1966) found that bulking rate increased with progressive increases in L.A.I. up to 3. For sprouted seed in this experiment, there was little relationship between bulking rate and the size of the foliage at tuber initiation ~~and~~ or bulking rate ~~or~~ and maximum foliage production ($r = 0.344$ N.S., d.f. 12 and $r = 0.203$ N.S., d.f. 12 respectively). Similarly Goodwin (1964) could find no relationship over a wide range of Leaf Area Index (L.A.I.) and bulking rate in Arran Pilot. However, for the unsprouted seed, bulking rate increased with an increase in foliage size at the time of tuber initiation ($r = 0.563$ *, d.f. 12) and also with an increase in the total amount of foliage ($r = 0.693$ *, d.f. 12). Although it is clear that high leaf area indices at tuber initiation result in high yields, largely as a result of a greater leaf area duration (Bremner and Radley, 1966), it is not clear whether the size of the foliage at tuber initiation has an effect on tuber number. Bremner and Radley (1966), using Ulster Torch, an early main crop, found that tuber initiation occurred at the same L.A.I. irrespective of the date of tuber initiation.

Differences in the number of tubers at harvest were largely due to differences in the number of tubers initiated, though the rate of tuber survival was important in a few cases. For sprouted seed these differences occurred irrespective of differences in mainstem numbers. Although it was apparent that the relief of the soil water deficit by rainfall during the period of tuber formation for planting dates 13 and 14 was associated with an increase in the number of tubers set, the overall relationship between tuber number and water content at the time of tuber formation was poor. Llewellyn (1962) has shown that watering whenever soil moisture tensions of 25 cm. Hg. were reached produced 63% more tubers than a treatment watered at a capillary tension of 50 cm. Hg. For the unsprouted treatment soil moisture tensions showed a greater variation (20 to 40 cm. Hg. during the period of tuber formation as opposed to 20 to 25 cm. Hg. in the sprouted treatment), and this may account for the better relationship between tuber numbers and soil water content in unsprouted seed.

In planting date experiments the pattern of growth is not always independent of plant age (Jackson, 1967), and as a result multiple regression analysis cannot be used in relating growth parameters to environmental factors since this assumes that factors are independent and additive in their effects.

In this experiment although the pattern of total dry weight with time did not appear to be affected by planting date, delay in planting resulted in progressively earlier tuber initiation relative to foliage development, possibly as a result of the increase in sprout development with delay in planting. Soil water content showed a marked trend with time, and thus its effects on tuber number cannot be separated from the effects of 1) an increasing sprout development in storage associated with an increasing number of mainstems in the field and 2) plant age at the time of tuber formation.

5. Conclusions

1. The relative performance of sprouted and unsprouted seed in regard to yield and tuber number is subject to variation probably in part due to differences in the environment encountered during tuber formation.

2. Differences in tuber number appear to be largely determined by the number of tubers formed although in a few cases differences in the rate of tuber survival are involved.

3. Differences in yield may arise from both differences in the length of the bulking period and also in the rate of bulking and the relative importance of each of these components can vary depending upon the growing conditions. Despite large fluctuations in the weather, the rate of dry matter production in the early stages of growth shows little variation.

Experiment 6: Shading experiment 1968

6. Introduction

The results from Experiment 1, Section I, for the unsprouted tubers, where low tuber numbers were associated with low bulking rates and slow rates of foliage growth early in the season, suggest that the relationship between haulm, tuber growth and the environment in the early stages of growth has a bearing on the number of tubers formed and the number surviving.

A high rate of supply of dry matter from the foliage (reflected in the rate of tuber bulking) has been related to the number of tubers (Goodwin, 1964; Burt, 1965) and it has been suggested (Burt, 1964b, 1965, 1966; Nosberger and Humphries, 1965; Gifford and Moorby, 1967) that the rate of tuber growth may be controlled by the activity of the 'sink', a greater number of tubers having a greater sink capacity. However, other field data (Bremner and Taha, 1966; Llewellyn, 1967) show no relationship between tuber numbers and bulking rates. In addition there is no relationship between Net Assimilation Rate (N.A.R.) and bulking rate (Burt, 1961) or mean Leaf Area Index (L.A.I.) during tuber bulking and bulking rate (Burt, 1961; Goodwin, 1964; Bremner and Radley, 1966). However, it is not clear whether the rate of carbohydrate supply determines the number of tubers formed.

Epstein (1966) demonstrated that with increasing temperature which favours haulm growth at the expense of tuber growth

(Burt, 1961, 1964a) tuber number falls at the time haulm growth is most rapid, though it is not clear from the results whether this was a result of fewer tubers being initiated, fewer surviving to harvest or both. Application of growth retardants to the foliage (Humphries and Dyson, 1967; Bodlaender and Algra, 1967, using B995 - N-dimethylamino succinamic acid; Dyson, 1965, and Gifford and Moorby, 1966, using C.C.C. - (2-chloroethyl) trimethyl ammonium chloride) during the early stages of tuber growth can result in an increase in tuber number at harvest. This was largely as a result of an increase in the number of tubers surviving to harvest and Lovell and Booth (1967) have suggested that a greater proportion of assimilate is available for tuber growth since no 'sink' is provided in the meristematic regions of the shoot.

In cereals a large Leaf Area Index (L.A.I.) at anthesis increases grain yield and number (Bremner, 1968). Similarly, in the potato, high yield and high tuber numbers are often associated (Broadbent et al., 1957; Goodwin, 1964; Bremner and Taha, 1966; Experiment 5, 1967). High leaf area indices (L.A.I.) at the time of tuber initiation and high leaf area durations result in high yields (Bremner and Radley, 1966) but it is not clear whether high leaf area indices (L.A.I.) at tuber formation result in an increase in the number of tubers initiated. Llewellyn (1967) has shown that tuber number and yield may be affected independently. Soil water deficits occurring during the early stages of tuber formation reduced tuber number more than when they occurred during the early stages of bulking. Yield, however, was more affected by soil water deficits during the early stages of bulking.

The object of Experiment 6 was to investigate more fully, by means of shading, the effects of stress at different stages of development, on foliage and tuber growth, tuber numbers and yield and their relationships.

7. Materials and methods

There were four treatments:

S 0. Control; no shading.

S 1. Shaded for a period of 10 days in the early stages of growth.

S 2. Shaded for a period of 10 days during the period of tuber formation.

S 3. Shaded for a period of 10 days after tuber initiation but during the early stages of tuber bulking.

Treatment 1 was abandoned because of damage to the plants after the collapse of the shading structure during a gale. The experiment was originally to have been laid out in a crop of F.S. Majestic but slow emergence led to considerable blanking and the site was moved to a commercial break of certificate 'A' Pentland Dell. As a result the experimental error was high.

The experiment was carried out on the University farms on a gravelly, sandy loam at 660'. The design was a randomised block with 10 replicates. Ninety units of N and P_2O_5 and 120 units of K_2O were broadcast before working. Machine planting of sprouted seed took place on 21st May. The spacing between setts was 15". Immediately after planting the ridges were split. Weeds were controlled by spraying with linuron (2 lb. A.I. per acre) in 30 gallons of water in early June. Plot size was 15.5 feet x 5 drills wide, the two outside drills acting as guard rows.

Samples of 3 plants per sample were taken from all the plots on 27th June, 5th July, 17th July, 25th July and 5th August. Mainstem and the total number of stems at ground level, foliage and tuber fresh weights and dry weights were recorded as in Experiments 1 and 2, Section I. Tuber numbers and weights in the grades 0-5g., 6-10 g. and 11-25g. were also recorded. In addition, measurements of leaf area were made by the method of Bremner and Taha (1966). The leaves were removed from a weighed sub-sample of the foliage, except at the first sampling occasion where all the foliage was used, and dropped on to a board. Leaf discs were taken at random with a punch of area 2.553 $cm.^2$ and the weight of 50 whole discs recorded. Actual leaf areas were determined by simple proportion. A final harvest of 9 plants per plot ($\frac{1}{1844}$ acre) was made on 14th September. Samples of about $\frac{1}{10}$ of the weight of the total plot yield were taken for dry matter

Table 71 - Length of the shading period and weather data over the periods of shading.

	Date of the start of shading	Date of removal of shades	Duration of shading
Shaded 2	5 July	17 July	12 days
Shaded 3	25 July	5 August	12 days

	Average air temperatures OF over the shading period		Total number of hours of bright sunshine over the shading period	Total rainfall in inches over the shading period
	Max.	Min.		
Shaded 2	56.4	45.9	29.0	3.04"
Between shading periods 2 and 3	63.3	49.3	34.1	0.64"
Shaded 3	63.7	48.4	77.4	0.025"

determinations.

The frame for the shades was made using scaffolding pipes. Ten oz. Hessian, which reduced the light intensity to between 12% and 17% of full daylight, was sewn to the frame. The area shaded was 16' x 3 centre drills. Although the hessian covered the two short ends of the construction to ground level the two side panels were covered to within 6" of ground level to allow a free flow of air through the structure and, as a result, in the first shading period there was some lateral penetration of light to the two outside rows of the plot. Light-meter readings showed that these two rows received light intensities over half their surface of between 25% and 30% of full daylight. In the second shading period the plants in the guard rows were much larger and effectively prevented the lateral penetration of light. Details of the lengths of the shading periods and the weather during this period are given in table 71.

8. <u>Results and Discussion</u>

Coefficients of variation were high during the sampling phase: of the order of 20% - 30%. At harvest coefficients of variation were between 10-20%.

Shading during the early stages of tuber formation (S 2) delayed the time of development of maximum tuber number relative to the control (S 0) but after the shades were removed from S 2 there was a large increase in the number of tubers formed (figure 29a). The number of tubers initiated was higher than the control (S 0) but this was not significant. There was a greater rate of tuber loss in S 0 compared with S 2 until the 5th sample lift. Thereafter rates of tuber loss in the three treatments were similar. As a result S 2 produced 30% more tubers at harvest (table 72). Bulking rates in S 0 and S 2 were similar (figure 30) and there was no significant difference in fresh or dry weight yield at harvest (table 72). The development of tuber number in S 3 was very similar to the control (S 0) and there were no significant differences between them in the number of tubers at harvest. However, S 3 reduced the yield, largely as a result of the marked reduction in tuber bulking rate, over the period of shading. The larger number of tubers in S 2 compared with S 0 and S 3 resulted in a greater yield of seed and smaller yield of ware than S 0 and S 3. Mainstem numbers were not affected (table 72).

There was no significant effect of shading at S 2 or S 3 on leaf area index (L.A.I.) over the period of shading compared with the control (S 0) (figure 31). However, after the period of shading in S 2, there was a considerable reduction in L.A.I. and foliage dry weight, but later a rapid recovery occurred and L.A.I.s in S 0, S 2 and S 3 were similar at sample lift 5. The poor recovery in leaf area in S 2 immediately after shading may have been due to the excessive demands on the carbohydrate supply for tuber growth during the tuber formation period but

Figure 29 Effect of shading on the change in tuber number with time.
a) tuber initials (<1g),
b) total tuber number.

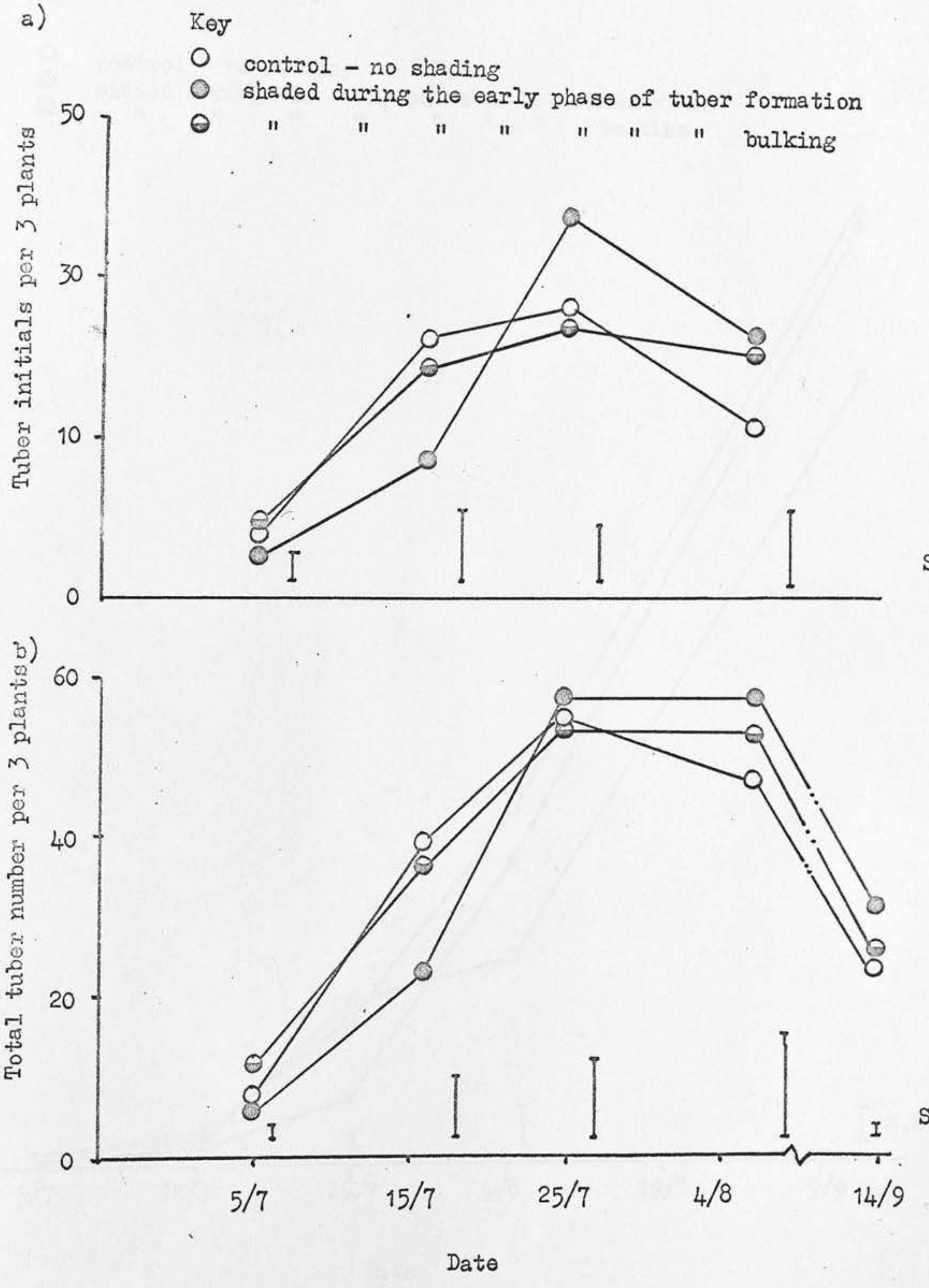


Figure 30 Effect of shading on the change in tuber fresh weight with time.

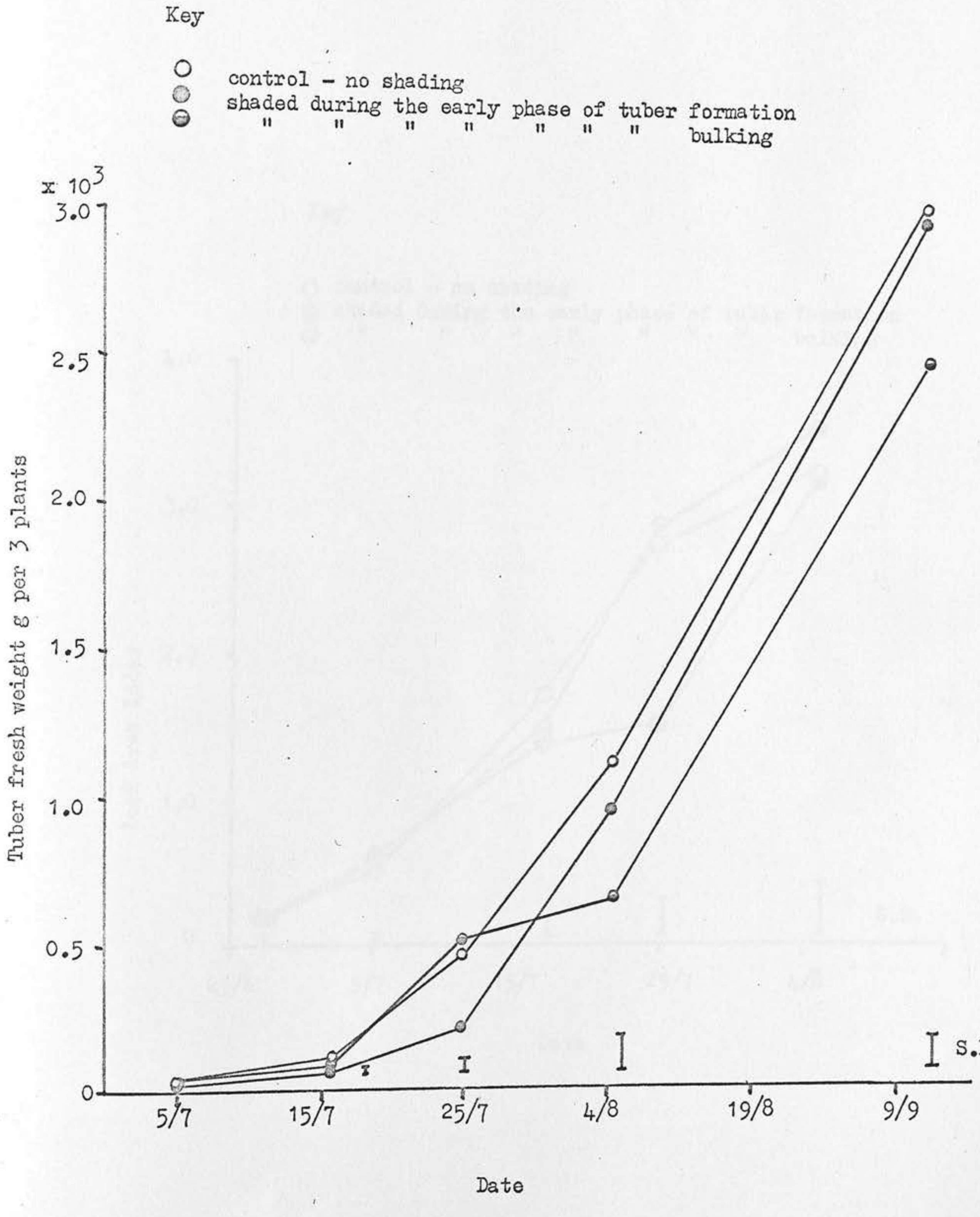
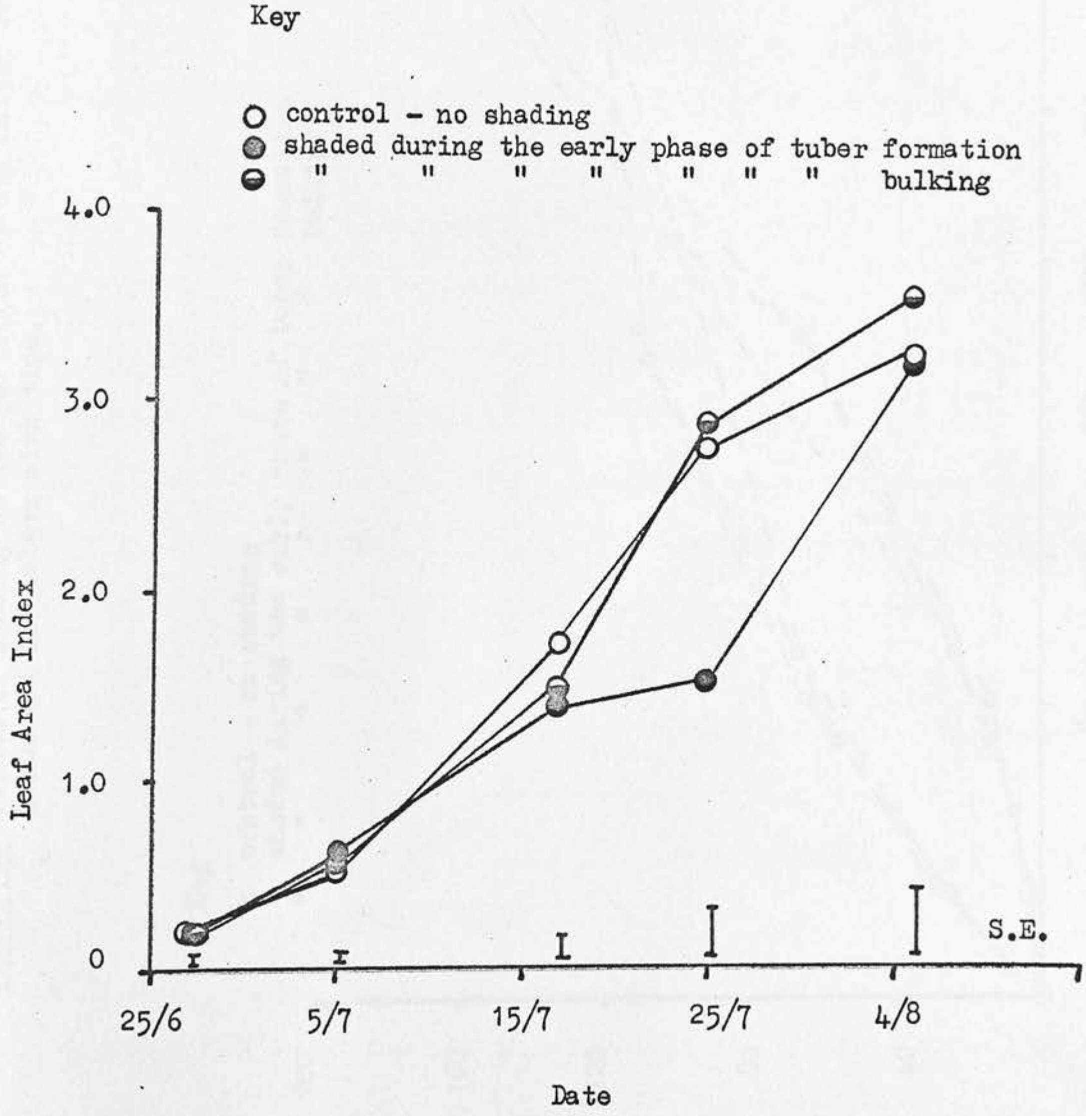
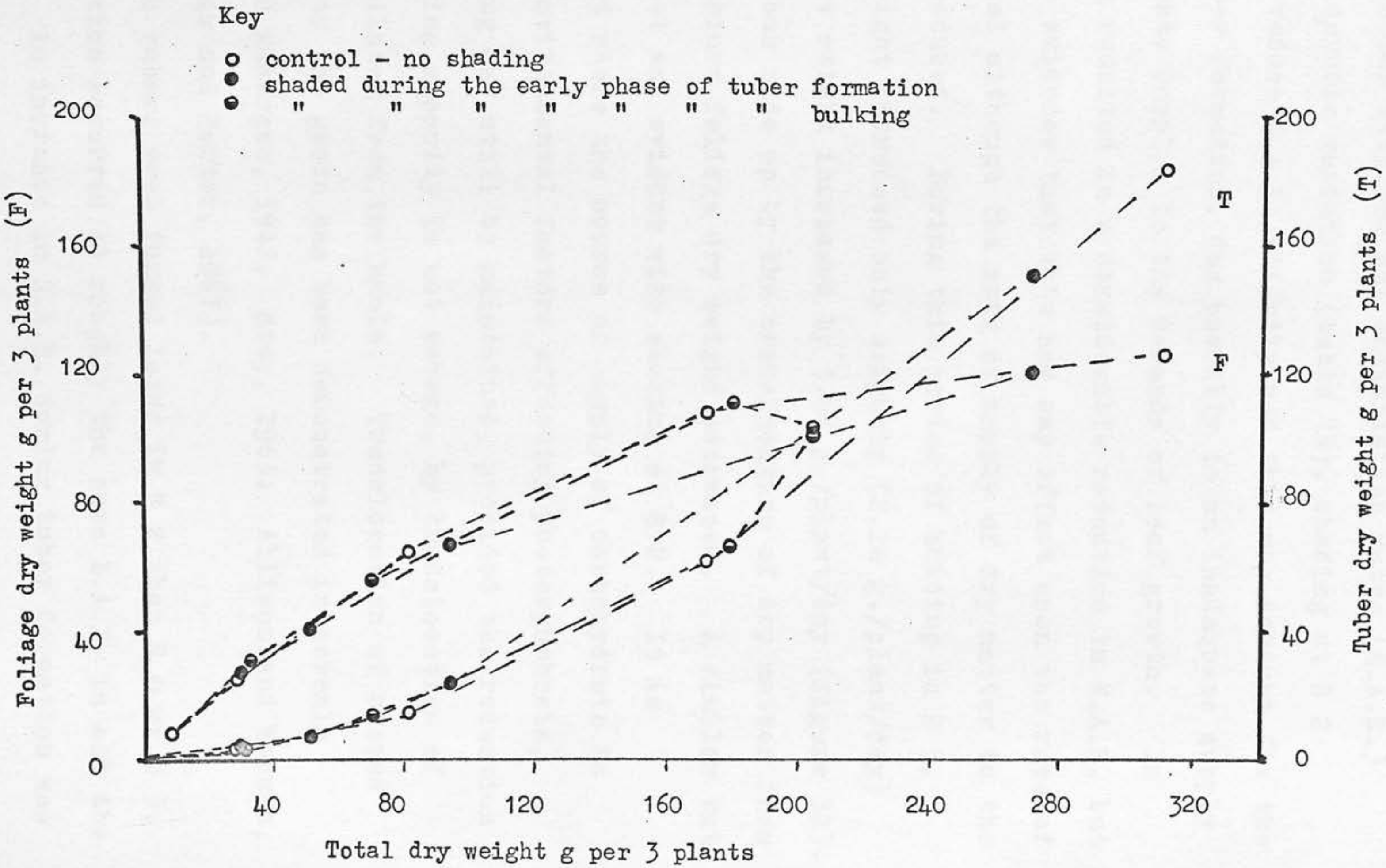


Figure 31 Effect of shading on the change in leaf area index (L.A.I.) with time.



<u>Figure 32</u> Effect of shading on the partition of dry matter between the haulm and the tubers with time.



once maximum tuber numbers were formed leaf growth recommenced.

Although the data for net assimilation rates (N.A.R.) showed considerable variation (table 76), shading at S 2 appeared to reduce N.A.R. slightly and this may account for the delay in tuber formation, due possibly to an inadequate supply of carbohydrate surplus to the demands of leaf growth. In S 3, shading resulted in a considerable reduction in N.A.R. but there was no evidence that this had any effect upon the rate of tuber survival although the rate of supply of dry matter to the tubers was reduced. During this period of shading in S 3, total dry weight increased only slightly (2.18 g./plant/day) but tuber dry weight increased by 3.04 g./plant/day (figure 32). The surplus was made up by the translocation of dry matter from the foliage since foliage dry weight decreased. A similar but smaller effect was evident with shading at S 2. It is possible that where the source of supply of carbohydrate is limited by environmental factors affecting photosynthesis, linear bulking may still be maintained, provided the reduction in assimilating capacity is not severe, by translocation of stored assimilates from the haulm. Translocation of stored assimilates to the grain has been demonstrated in cereals (Archbold and Mukergee, 1942; Stoy, 1963; Allison and Watson, 1966; Wardlaw and Porter, 1967).

Although tubers were formed later in S 2 than S 0 or S 3, tuber initiation occurred at roughly the same L.A.I. in all the treatments. An increase in N.A.R. during tuber formation was

Table 72 - Effect of shading treatment on tuber yield and tuber number, percentage dry matter content of the tubers, dry matter yields all at final harvest and mainstems per hill.

Treatment		Yields (tons per acre)			Total tuber number	Percentage dry matter of the tubers	Dry matter yield	Mainstems per hill
		Total	Ware	Seed	(10^3 per acre)		(tons per acre)	
Control	S0	14.69	4.65	9.82	117.5	20.80	3.06	2.3
Shaded during tuber formation	S2	14.53	2.70	11.44	153.8	19.92	2.90	2.2
Shaded during the early phases of tuber bulking	S3	12.24	3.49	8.42	128.5	19.89	2.43	2.2
S.E.		±0.516	±0.419	±0.480	±5.82	±0.301	±0.122	±0.12

Table 73 - Effect of shading treatment on tuber dry matter (g per 3 plants) with time.

Treatment		Sample lift				
		1st shading period		2nd shading period		Final harvest
		2	3	4	5	
Control	S0	3.2	15.2	63.5	184.3	624.5
Shaded during tuber formation	S2	2.3	8.5	25.5	151.4	591.9
Shaded during early phase of tuber bulking	S3	3.5	14.9	67.2	100.7	495.9
S.E.		±1.36	±1.56	±6.54	±20.23	±24.90

Table 74 - Effect of shading treatment on foliage dry matter (g per 3 plants) with time.

Treatment		Sample lift	1st shading period		2nd shading period	
		1	2	3	4	5
Control	S0	9.0	24.5	65.9	109.2	126.7
Shaded during tuber formation	S2	9.0	26.6	42.9	68.6	120.4
Shaded during early phase of tuber bulking	S3	9.3	30.0	56.2	112.8	103.6
S.E.		±0.87	±1.85	±4.62	±9.37	±11.34

Table 75 - Effect of shading treatment on total dry matter (g per 3 plants) with time.

Treatment		Sample lift 1	1st shading period 2	3	2nd shading period 4	5
Control	S0	9.0	27.7	81.1	172.7	311.0
Shaded during tuber formation	S2	9.0	28.9	51.4	94.1	271.8
Shaded during early phase of tuber bulking	S3	9.3	33.5	71.1	180.0	204.3
S.E.		±0.87	±2.2	±5.49	±14.83	±30.86

Table 76 - Effect of shading treatment on Net Assimilation Rate, (g/dm^2/week) with time.

		Sample periods			
		1 - 2	2 - 3	3 - 4	4 - 5
Control	S0	0.668	0.753	1.695	1.118
Shaded during tuber formation	S2	0.697	0.512	1.155	1.360
Shaded during early phase of tuber bulking	S3	0.764	0.710	1.730	0.225
S.E.		±0.079	±0.140	±0.203	±0.274

noted by Gifford and Moorby (1967) and it is clear from the work of Nosberger and Humphries (1965) and Burt (1966) that the size of the 'sink' can control the rate of assimilation. In this experiment there was an increase in N.A.R. during the period of tuber formation but this is confounded with differences in air temperature and radiation which occurred between the first and second shading periods. An increase in air temperature has been shown to increase N.A.R. in the potato (Watson, 1947). In S 0 and S 3 maximum tuber numbers were formed when the N.A.R. was low. In S 2 tuber formation was delayed relative to S 0 and S 3 and tubers were formed during a period when the N.A.R. was much higher. The apparent correlation between the rapid increase in tuber number in S 2 after the shading period and the high N.A.R. suggests that the high light intensities and high temperatures over the period of tuber formation in S 2 resulted in higher rates of assimilation and higher rates of carbohydrate supply to the tuber sites. However, in view of the high experimental errors, it would be desirable to test these effects under controlled environmental conditions taking more frequent samples and measuring rates of photosynthesis, respiration and translocation of the products.

9. Conclusions

1. It is suggested that differences in tuber number at harvest are related to differences in the assimilatory rate of the plant at the time of tuber initiation. Changes in tuber yield and tuber number did not appear to be related.

2. There is some evidence that translocation of stored assimilates from the haulm to the tuber occurs during tuber growth which may supplement the normal supply of carbohydrates from the leaves when the assimilatory rate is low.

Chapter III

FINAL DISCUSSION

A summary of the data on sprout and stem number, tuber number and yield for the years 1965-67 is given in table 77. For the purposes of this discussion November, December and January-sprouted seed tubers are referred to as early-sprouted seed tubers and February and March-sprouted seed tubers as late-sprouted seed tubers.

On average sprouted seed out-yielded unsprouted seed in Arran Pilot by about 1 ton per acre and in Majestic by about 0.6 tons per acre: increases of 7% and 4% respectively. This was largely brought about by the large differences in yield in 1965 where sprouted seed out-yielded unsprouted seed by 12½% in Arran Pilot and by 15% in Majestic. In other years there was little difference in yield. These results confirm the work of the authors mentioned previously and with the results from the series of experiments carried out at Edinburgh between 1961-64 which are discussed in more detail in the Introduction (table 1). There was in 1966 (Experiment 3) a reduction in yield with cold-stored tubers (40^{o}F) compared with unsprouted tubers (35^{o} - 45^{o}F) in both Arran Pilot (2 tons per acre) and Majestic (2.3 tons per acre): reductions of 12½% and 13½% respectively. This may be an isolated effect since Lennard (1966, 1967) found no difference in yield between tubers stored at 39^{o}F and at 43^{o}F over two

Table 77 - Summary of the effect of sprouting seed tubers compared with unsprouted seed tubers on sprout and stem development, tuber number and yield over the years 1965-1967.

ARRAN PILOT

	Sprout number per tuber	Sprouts >8 mm per tuber	Main-stems per hill	Total stems per hill	Total tuber yield (tons per acre)	Total tuber number (10^3 per acre)	Seed yield (tons per acre)
1965 Experiment 1							
Sprouted November	4.3	2.29	2.03	7.96	13.11	140.8	7.85
Sprouted March	6.1	3.02	2.90	10.33	13.29	166.0	9.30
Unsprouted	-	-	3.49	5.47	11.74	147.8	8.85
S.E.			±0.119	±0.191	±0.300	±4.63	±0.254
1966 (i) Experiment 2							
Sprouted December	6.7	2.72	2.32	8.59	-	259.0	-
Sprouted March	10.2	3.24	2.67	7.40	-	267.0	-
Unsprouted	-	-	3.51	5.01	-	229.0	-
S.E.			±0.075	±0.312	-	±16.8	-
1966 (ii) Experiment 3							
Sprouted January	9.2	2.9	2.0	8.1	17.78	152.2	8.45
Sprouted March	10.3	3.8	2.8	8.6	15.52	135.6	7.60
Unsprouted	-	-	3.8	5.1	16.69	128.9	7.63
Cold stored (40°F)	-	-	3.9	6.0	14.71	127.0	8.20
S.E.			±0.15	±0.33	±0.651	±5.10	±0.327
1967 Experiment 4							
Sprouted November	5.6	-	1.6	7.8	17.44	112.1	5.22
Sprouted March	9.2	-	3.2	8.7	17.33	127.2	6.11
S.E.			±0.10	±0.33	±0.873	±4.99	±0.324

Table 77 (contd.)

MAJESTIC

	Sprout number per tuber	Sprouts >8 mm per tuber	Main-stems per hill	Total stems per hill	Total tuber yield (tons per acre)	Total tuber number (10^3 per acre)	Seed yield (tons per acre)
1965 Experiment 1							
Sprouted November	3.9	1.36	1.61	5.34	16.08	142.9	8.58
Sprouted March	5.0	1.74	2.14	5.79	15.42	136.9	7.97
Unsprouted	-	-	2.74	3.19	13.59	129.6	7.94
S.E.			±0.119	±0.191	±0.300	±4.63	±0.254
1966 (i) Experiment 2							
Sprouted December	9.0	2.00	1.83	4.82	-	258.0	-
Sprouted March	12.4	3.72	2.67	5.35	-	281.0	-
Unsprouted	-	-	3.51	3.69	-	291.0	-
S.E.			±0.075	±0.312	-	±16.8	-
1966 (ii) Experiment 3							
Sprouted February	8.4	2.3	2.3	4.1	18.97	138.7	7.72
Sprouted March	9.7	2.7	2.4	4.6	17.56	131.7	7.00
Unsprouted	-	-	2.9	3.3	18.23	132.4	7.34
Cold stored (40°F)	-	-	3.4	3.6	15.90	124.7	7.55
S.E.	-	-	±0.15	±0.33	±0.651	±5.10	±0.327
1967 Experiment 5							
Sprouted February	10.8	2.18	1.99	4.63	17.39	104.4	4.28
Unsprouted	8.9	0.18	2.71	2.85	17.01	97.4	4.23
S.E.			±0.036	±0.05	±0.18	±1.27	±0.079

years of trials in a large number of varieties including Arran Pilot and Majestic.

In the years where growth data were available, differences in yield appeared to be due to differences in both the rate and duration of bulking though as in the results of Bremner and Radley (1966) the relative importance of these two parameters varied with season and variety.

In all cases delay in setting up for sprouting of previously cold-stored tubers resulted in an increase in sprout number and stem number. Unsprouted seed produced the greatest number of mainstems. Early-sprouted tubers generally showed a greater degree of lateral-branch development of the sprouts than late-sprouted tubers. Generally, Arran Pilot produced more mainstems and showed, in sprouted seed, a greater degree of lateral-branch development of the sprout than Majestic. These results confirm those of Toosey (1963, 1964) and others. Although the number and size of sprouts at planting time showed considerable variation from year to year similar numbers of mainstems and stems at ground level developed in the field under the sprouting treatments. However, in contrast to Toosey (1963, 1964), there was considerable variation in the response in tuber number to an increase in mainstem number from year to year and in view of this it is difficult to maintain the views of Holliday (1960) and Toosey (1963, 1964) that main-stem numbers are a precise guide to tuber number in all situations. Further discussion of this point will be found later.

On average in Arran Pilot, late-sprouting produced 10% more tubers than unsprouted seed, the pattern of response to these two treatments being similar in each year. Only in 1966 (Experiment 3) did early-sprouting produce more tubers than late-sprouting. In 1966 (Experiments 2 and 3) early-sprouting produced on average 12% more tubers than unsprouted seed but when all the years are considered unsprouted seed produced 2% more tubers than early-sprouted seed. In Majestic the response to the treatments did not appear to be so large. Early-sprouting in 1965 produced more tubers than late-sprouting or unsprouted seed but this was reversed in 1966. In four experiments out of five, late-sprouting produced more tubers than unsprouted seed but in each case the increase was small (2-7%). These results are in agreement with Eckersall and Bremner (1963) who found little response in tuber number to sprouting treatments in either King Edward or Majestic in one trial and the results from the Edinburgh series of experiments from 1961-64 (table 1).

The practice of setting up tubers to sprout in February or March to increase both tuber yield and number would appear to offer little advantage over unsprouted seed in Majestic. At least in terms of tuber number, Arran Pilot appears to be more responsive. However, in assessing the value of this practice other factors need to be considered. Where the growing season is curtailed by either blight attacks as in 1965 or by the weather conditions during the later stages of growth (North of

Scotland College of Agriculture, 1937, 1939; Toosey, 1964) sprouted seed usually out-yields unsprouted seed though the reduction in yield in unsprouted seed is less in early varieties as opposed to main crop varieties (North of Scotland College of Agriculture, 1937, 1939). Where the early-growing season is wet and cold sprouted seed usually shows less blanking than unsprouted seed except possibly in Pentland Dell where under these conditions sprouted seed may show extensive blanking due to 'little potato' formation. Although reductions in stand do not necessarily reduce total yield (Davies, 1954; Haughdal, 1957) the reduction in stem density is likely to have an adverse effect on tuber numbers and seed yield (Holmes, 1966b). In this connection if skin spot (Oospora pustulans) is severe in unsprouted seed, bud growth is prevented and serious blanking can result reducing the number of tubers and the yield of seed. In addition, a reduction in stem numbers in unsprouted seed can result if a number of eyes are infected (Boyd and Lennard, 1961). In these experiments the level of skin spot infection was not severe on the stocks of seed used, and it is unlikely that stem numbers in the unsprouted treatment were affected. Earlier lifting in drier, warmer conditions which can be achieved with sprouted crops offers a means of controlling skin spot (Boyd, 1957; McGee, 1967). The warm conditions when setting up to sprout may prevent losses of tubers due to gangrene (Phoma foveata) infection (Malcolmson and Gray, 1968) but this may increase the development of dry rot (Fusarium caeruleum).

If sprouting is to be undertaken for seed production, seed may be set up to sprout at any time between late January and March. It may be necessary in unheated stores to raise the temperature to $50^{\circ} - 55^{\circ}F$ for two or three weeks to encourage bud growth and if this is done before mid-February skin spot infection of the buds may be reduced. Desprouting seed tubers has been suggested as a way of increasing tuber number and seed yield. However, deliberately setting up the tubers to sprout early and then desprouting and resprouting is unlikely to produce more tubers and higher seed yields than setting up tubers to sprout at the time of desprouting. Provided, however, that skin spot does not affect regrowth, desprouting is unlikely to reduce tuber number or seed yield.

Overall there was a poor relationship between mainstem and tuber number in both Arran Pilot and Majestic, largely as a result of the opposite trends in mainstem and tuber number between the years. In Arran Pilot $r = < -0.1$ N.S., d.f. 12 and in Majestic $r = -0.62$ N.S., d.f. 6 - calculated as an analysis among treatments and within years. There appeared to be a better relationship between the total number of stems at ground level and tuber number in Arran Pilot but the relationship was not significant: $r = 0.42$ N.S., d.f. 12. There was no significant relationship in Majestic: $r = 0.1$ N.S., d.f. 6.

Small differences in sprout development in Arran Pilot arising from the previous history of the mother crop and from clipping the sprouts at different stages of sprout development to induce different proportions of leafy branches and stolon-like branches had little effect on stem or tuber production. Larger differences in sprout development, reflected in the number of lateral branches produced on large as opposed to small sprouts, did result in differences in stem and tuber production. However, a unit increase in lateral branches does not have such a large effect on tuber number as a unit increase in mainstem number. In general, an increase in the index of sprout development at planting (lateral branches + sprouts per tuber) results in an increase in stem and tuber number as was found by Goodwin (1964) but here, over all the experiments, the relationship was poor. Majestic proved to be unresponsive to efforts to induce lateral branching but in 1965 the incidence of 'coiled-sprout' led to an increase in the number of lateral branches and tubers produced.

Early-sprouted tubers generally result, in both varieties, in the production of more lateral branches per sprout than late-sprouted tubers and this may explain the small response of late sprouting over early sprouting in tuber number despite differences in mainstem number, e.g. Experiment 1 in Majestic previously mentioned and Experiment 3 where delay in setting up for sprouting resulted in only a small increase in mainstems (9%) but a decrease in the total number of stems at ground level of 22% and tuber numbers of 20%. This was due presumably to the shorter time allowed for the development of the lateral branches compared with the earlier date of sprouting. Similar considerations also apply to the comparison between sprouted and unsprouted seed since the latter shows little lateral-branch development. In other cases, for example in Experiment 3, where cold-stored tubers (40^{o}F) (T6) and unsprouted tubers stored at 35^{o} - 45^{o}F (T7) produced similar numbers of mainstems but T6 produced fewer tubers, suggest that factors other than stem number are involved.

From the planting date experiment it was clear that, in Majestic, differences in the environment during the early stages of growth can produce differences in tuber number irrespective of changes in mainstem density. There were indications that differences in tuber number were related to differences in soil water content during tuber formation. However, it was not clear whether the interaction in tuber number between the sprouting treatment (sprouted vs. unsprouted seed) and planting date was due to the differences in the pattern of soil water content over the period of tuber formation or to a storage factor over the period of planting which led in unsprouted seed to an increase in mainstem number with delay in planting.

In 1965 and 1966 water supply was adequate over the period of tuber formation. However, there were differences in air temperature and radiation during the period of tuber formation. In 1965 tuber initiation occurred in the unsprouted crop during a cold spell accompanied by low radiation relative to the sprouted treatments. Foliage growth and tuber bulking were slow and few tubers were formed. Yield at final harvest was also reduced. Although high tuber numbers were associated with high yields in the planting date experiment, which could possibly suggest that high tuber numbers determine in some way the partition of more carbohydrate to the tubers, there was little relationship between bulking rate and tuber number except in 1965 in Majestic where there was a positive relationship. As Bremner and Taha (1966) have suggested, it is unlikely that the size of the 'sink' (defined in terms of the number of tubers) determines the rate of tuber bulking, since in these experiments more tubers were formed than survived to harvest. It was suggested, therefore, that the size of the 'source' was more important in determining yield. It seems likely also that the amount of carbohydrate available determines the number of tubers formed. Although the differences in foliage development and tuber number in 1965 between sprouted and unsprouted seed were confounded with differences in stem numbers, there is an indication that the size of the 'source' around the time of tuber formation determined the number of tubers set. In Experiment 6, however, tuber number varied independently of the size of the leaf system at the time of tuber initiation. Similarly Radley (1963) could show no relationship between the size of the leaf system at tuber initiation and tuber number. It appeared from Experiment 6 that environmental conditions, e.g. high light intensity and temperatures of 50-60^{o}F favouring high assimilation rates, resulted in an increase in tuber number but once the maximum number of tubers were formed differences in the rate of assimilation did not appear to affect the rate of tuber survival. Although in Experiments 1 and 2 differences in tuber number appeared to be due only to differences in the number of tubers initiated, rates of tuber survival also played a part in determining the number of tubers produced in Experiment 5.

In some of Toosey's experiments, where he used sprouted seed, sprouts were removed from sprouted tubers to obtain a given mainstem density. The sprouts were thus all at similar stages of development. In this case and in the case of seed size and spacing experiments in general, where there is a good measure of agreement between mainstem number and tuber number, the stem units described are similar in morphology.

In the sprouting experiments described here sprout development at planting and the environmental conditions at tuber initiation showed considerable variation between the treatments. In these cases mainstem numbers may be an imprecise guide to tuber number in practice.

Chapter IV

CONCLUSIONS

1. The response in yield and tuber number to sprouting is very variable from year to year but on average there is little advantage in yield between sprouted or unsprouted seed in either Arran Pilot or Majestic provided the crops mature naturally.

Late-sprouting in Arran Pilot gives on average more tubers than unsprouted seed (10%) and early-sprouted seed. The advantage of late-sprouting over unsprouted seed in Majestic is much smaller (3%).

2. Differences in response to the treatments in tuber number at harvest are largely due to differences in the number of tubers formed rather than to differences in the rate of tuber survival though differences in the rate of tuber survival do occur.

3. The increase in tuber numbers with delay in setting up for sprouting is largely due to an increase in the number of mainstems but the degree of lateral-branch development is also important, particularly in Arran Pilot where lateral-branch development of the sprout occurs during growth in storage.

4. Differences in response to sprouting between the years can be related to both the degree of sprout development at planting time and to differences in the environment, particularly at the time of tuber formation rather than at other stages of growth but not to differences in the previous history of the mother crop.

Chapter V

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APPENDIX

Figure 1 Maximum and minimum temperatures in the sprouting store (S) and the cool store (C) over the storage period 1964-65.

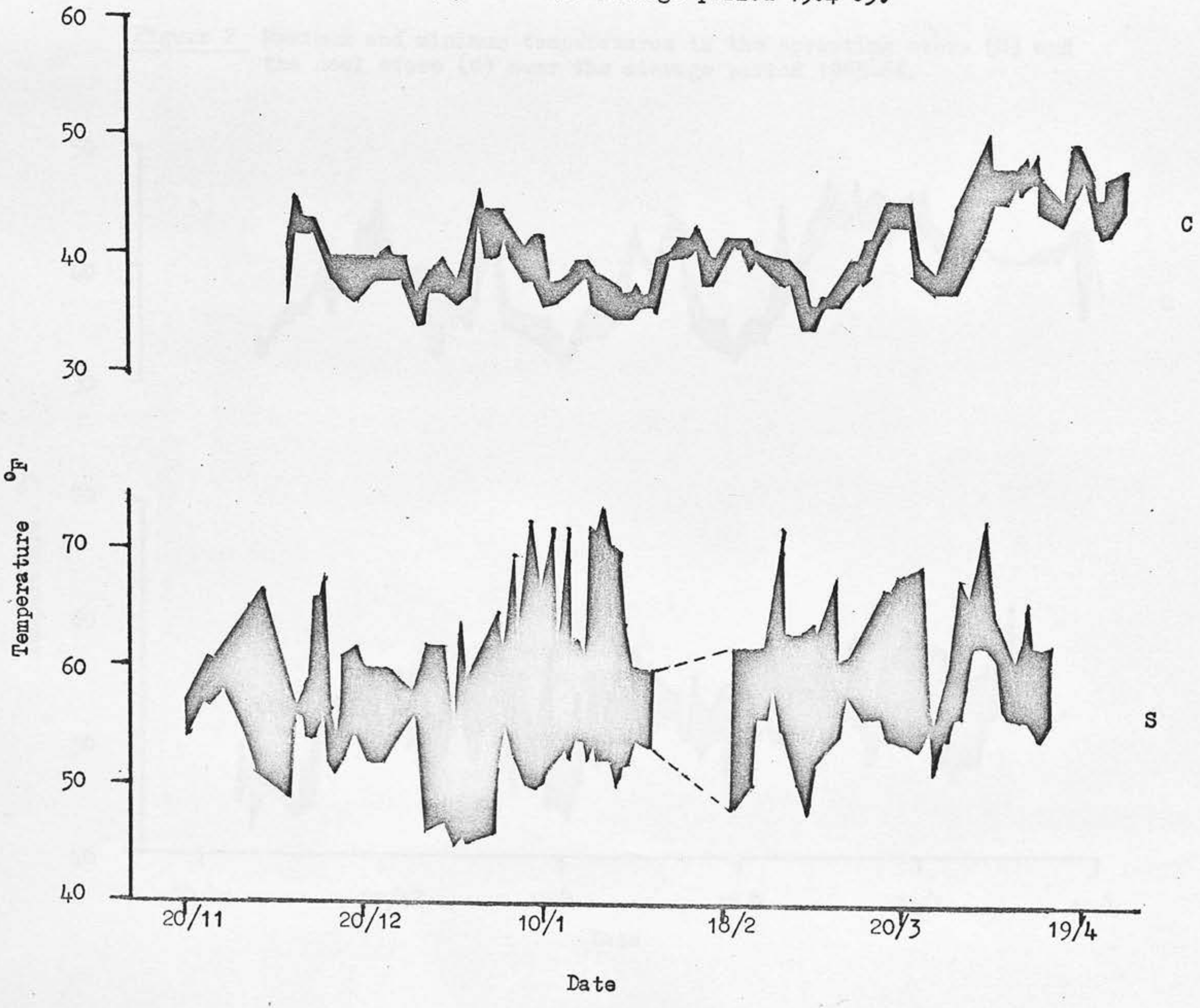

Figure 2 Maximum and minimum temperatures in the sprouting store (S) and the cool store (C) over the storage period 1965-66.

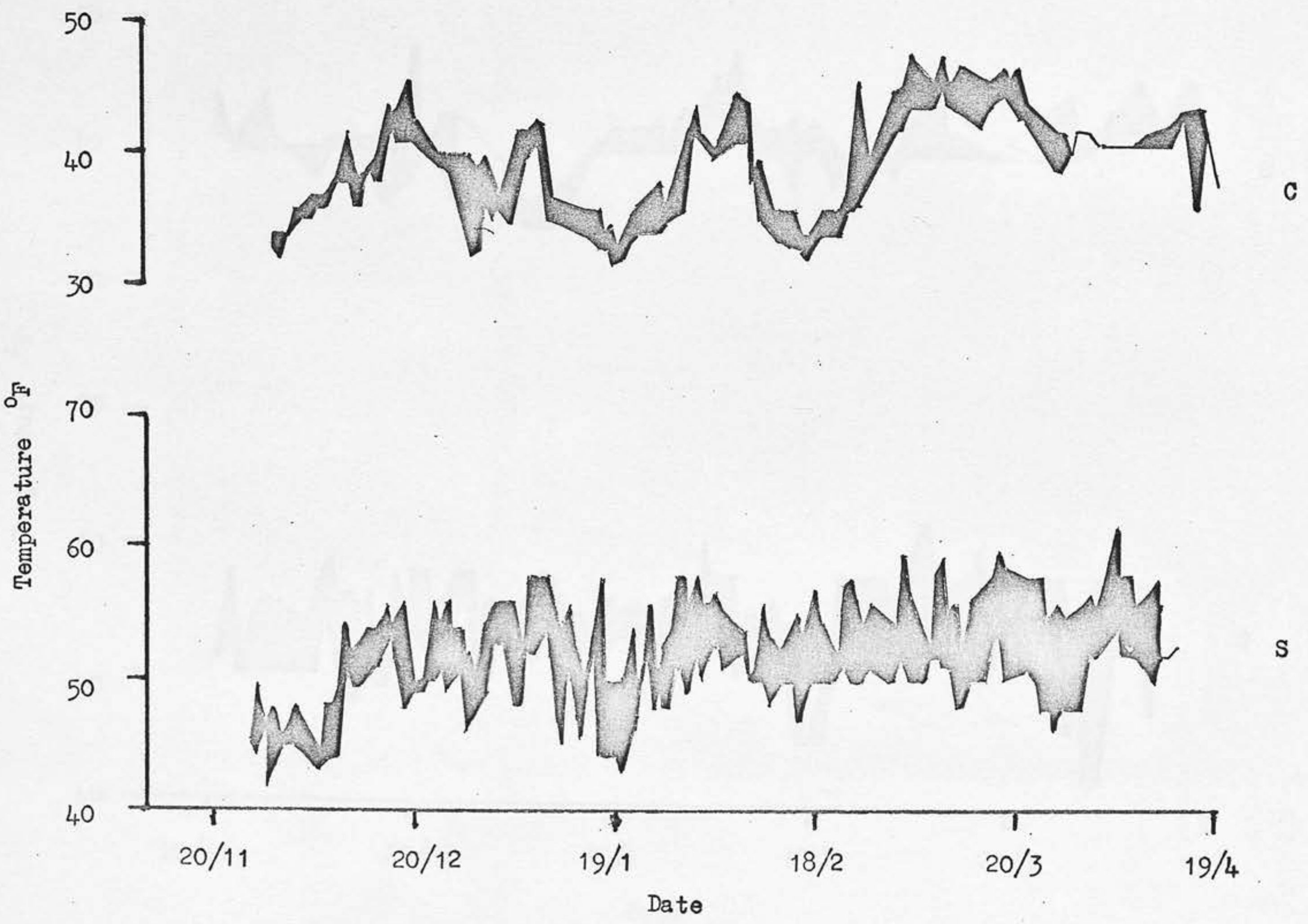

Figure 3 Maximum and minimum temperatures in the sprouting store (S) and the cool store (C) over the storage period 1966–67.

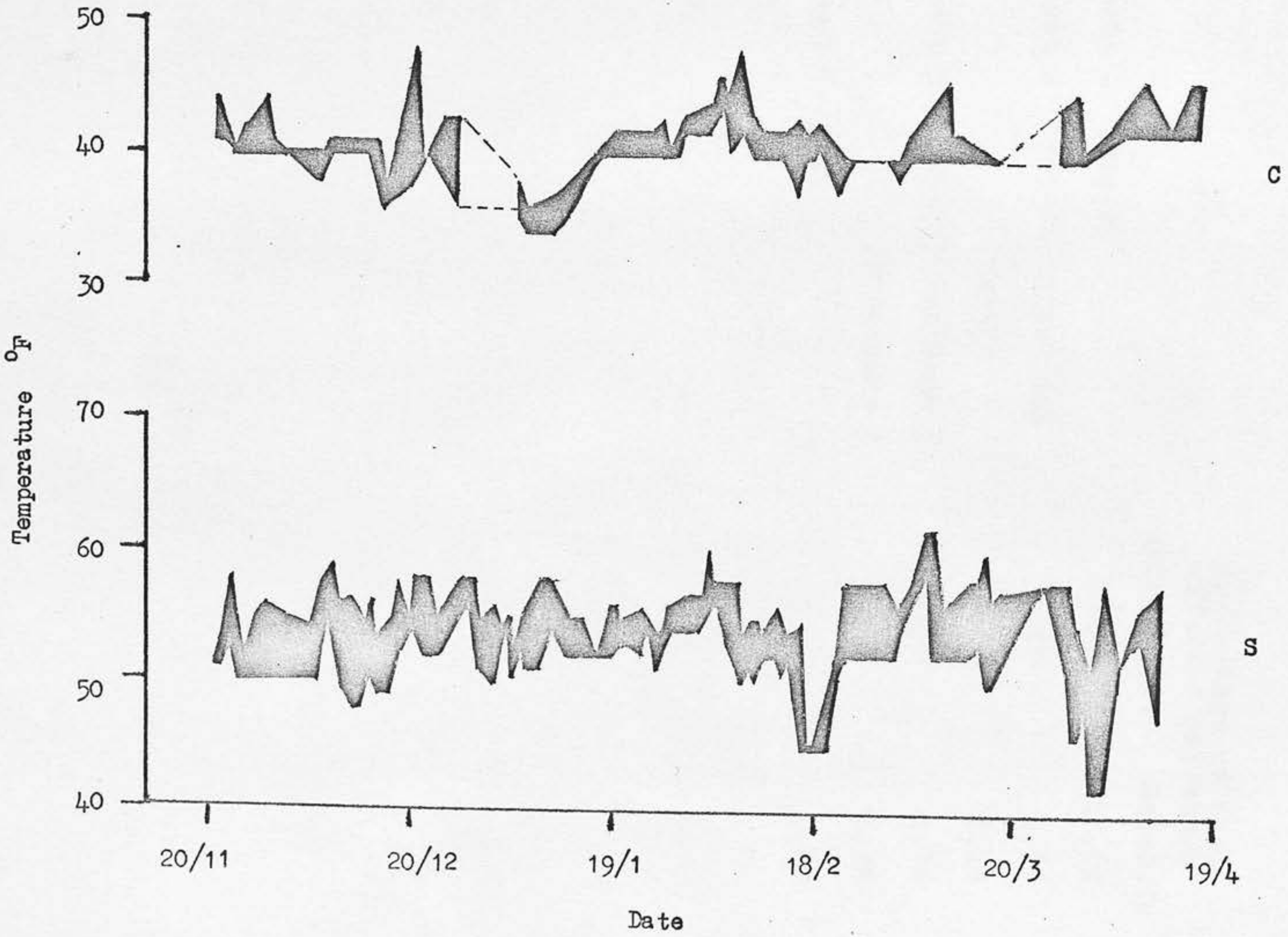

Table 1 - Skin spot assessment at planting time in unsprouted tubers.

		Percentage of eyes affected per tuber	
		Arran Pilot	Majestic
Experiment 1 1964-65		18.0%	12.0%
Experiment 2 1965-66	burned off	2.5%	1.5%
	mature	6.0%	2.5%
Experiment 3 1965-66	Treatment 6	1.6%	1.7%
	Treatment 7	0.3%	0.3%
Experiment 5 1967		-	7.5%

Table 2 - Sample tuber weights.

Experiment 1 1964-65

(g/5 tubers)

		ARRAN PILOT				MAJESTIC			
		Rep I		Rep II		Rep I		Rep II	
		Large	Small	Large	Small	Large	Small	Large	Small
N	I	490	239	469	257	482	244	475	265
	A	510	244	486	265	537	246	536	242
	M	475	260	478	240	476	262	477	242
	O	490	246	471	247	533	269	476	256
M	I	485	244	504	262	515	264	505	279
	A	500	248	500	246	478	256	509	264
	M	490	253	490	254	480	276	510	276
	O	496	266	494	261	525	253	518	265
O	I	499	274	474	276	495	242	487	255
	A	505	255	487	254	533	260	495	260
	M	480	255	500	250	510	271	482	275
	O	504	246	485	268	467	250	517	245

Table 2 (contd.)

Experiment 2 1965-66

	ARRAN PILOT		MAJESTIC	
	Large (g/5 tubers)	Small (g/10 tubers)	Large (g/5 tubers)	Small (g/10 tubers)
A - N mature	473	491	548	635
N burned off	493	488	540	632
M mature	502	504	546	640
M burned off	484	504	545	630
O mature	488	496	540	641
O burned off	483	480	534	641
B - N mature	493	500	548	639
N burned off	503	494	545	623
M mature	517	491	540	645
M burned off	506	491	545	628
O mature	491	483	548	633
O burned off	492	490	553	640
C - N mature	480	478	552	638
N burned off	485	482	544	655
M mature	521	490	543	640
M burned off	484	495	551	634
O mature	485	500	547	639
O burned off	487	474	550	640

Table 2 (contd.)

Experiment 3 1965-66

	ARRAN PILOT		MAJESTIC	
	Large	Small	Large	Small
	(g/10 tubers)			
Treatment 1	978	595	1150	658
2	994	595	1151	648
3	986	604	1143	659
4	982	604	1140	656
5	972	596	1149	651
6	988	596	1141	655
7	993	599	1159	667

Experiment 4 1966-67

	Large	Intermediate (g/10 tubers)	Small
Treatment 1	1139	788	509
2	1155	807	492
3	1167	816	513
4	1140	769	499
5	1167	804	511
6	1146	789	495
7	1143	797	497
8	1143	817	490

Table 2 (contd.)

Experiment 5 1967

Planting date	Sprouted Large	Sprouted Intermediate	Sprouted Small	Unsprouted Large	Unsprouted Intermediate	Unsprouted Small
			(g/10 tubers)			
1	1270	722	452	1210	797	458
2	1256	814	433	1143	785	452
3	1236	795	460	1244	793	463
4	1268	784	443	1253	808	444
5	1249	793	463	1214	762	457
6	1207	779	440	1244	781	443
7	1207	751	469	1201	795	447
8	1272	722	453	1217	777	451
9	1264	766	464	1248	777	444
10	1233	782	460	1207	720	455
11	1260	779	440	1219	796	457
12	1245	784	450	1236	823	456
13	1235	791	462	1271	824	453
14	1251	782	478	1236	762	452

Table 3 - Dates of setting up tubers for sprouting, movement of trays during the storage period and sprout removal.

Experiment 1 1964-65

Arran Pilot	Cool stored at 35°-45°F before setting up to sprout	Set up to sprout at 50°-55°F	Transferred to 35°-45°F from 50°-55°F	Desprouted before planting
All N[1] sprouted treatments	Harvest until 19/11/64	19/11/64	23/12/64	-
All M[1] sprouted treatments	Do. 1/ 3/65	1/ 3/65	9/ 4/65	-
All O[1] stored treatments	Do. to planting	-	-	13/4/65
Majestic				
All N[1] sprouted treatments	Harvest until 19/11/64	19/11/64	3/ 2/65	-
All M[1] sprouted treatments	Do. 1/ 3/65	1/ 3/65	9/ 4/65	-
All O[1] stored treatments	Do. to planting	-	-	-

Experiment 2 1965-66

Arran Pilot				
All A sprouted treatments	Harvest until 29/11/65	29/11/65	21/ 1/66	-
All B sprouted treatments	Do. 8/ 3/66	8/ 3/66	13/ 4/66	-
All C stored treatments	Do. to planting	-	-	12/4/66
Majestic				
All A sprouted treatments	Harvest until 3/12/65	3/12/65	25/ 2/66	-
All B sprouted treatments	Do. 8/ 3/66	8/ 3/66	13/ 4/66	-
All C stored treatments	Do. to planting	-	-	-

Table 3 (contd.)

Experiment 3 1965-66

	Cool stored before sprouting $35^{o}-45^{o}F$	Date of sprouting at $50^{o}-55^{o}F$	Date desprouting and resprouting at $50^{o}-55^{o}F$	Date of transfer from $50^{o}-55^{o}F$ to $35^{o}-45^{o}F$	Date of clipping sprouts
Arran Pilot					
Treatment					
1	Harvest until 15/12/65	15/12/65	21/1/66	23/2/66	-
2	17/ 1/66	17/ 1/66	1/3/66	29/3/66	-
3	17/ 1/66	17/ 1/66	-	23/2/66	-
4	1/ 3/66	1/ 3/66	-	29/3/66	-
5	17/ 1/66	17/ 1/66	-	23/2/66	6/4/66
6	Cool stored $40^{o}F$	-	-	-	-
7	Harvest until planting	-	8/4/66	-	-
Majestic					
Treatment					
1	Harvest until 15/12/65	15/12/65	25/2/66	24/3/66	-
2	17/ 1/66	17/ 1/66	1/3/66	5/4/66	-
3	22/ 2/66	22/ 2/66	-	5/4/66	-
4	1/ 3/66	1/ 3/66	-	13/4/66	-
5	17/ 1/66	17/ 1/66	-	24/3/66	6/4/66
6	Cool stored $40^{o}F$	-	-	-	-
7	Harvest until planting	-	8/4/66	-	-

Table 3 (contd.)

Experiment 4 1966-67

	Cool stored before sprouting at $35^{o}-40^{o}F$	Date of sprouting	Date of desprouting to a single sprout	Date of transfer from $50^{o}-55^{o}F$ to $35^{o}-45^{o}F$	Date of clipping
Treatment					
1	Harvest until 19/11/66	19/11/66	-	5/1/67	-
2	19/11/66	19/11/66	20/12/66	5/1/67	-
3	19/11/66	19/11/66	20/12/66	5/1/67	4/1/67
4	19/11/66	19/11/66	20/12/66	5/1/67	28/2/67
5	27/ 2/67	27/ 2/67	-	24/3/67	-
6	27/ 2/67	27/ 2/67	13/ 4/67	24/3/67	-
7	27/ 2/67	27/ 2/67	13/ 4/67	24/3/67	25/3/67
8	27/ 2/67	27/ 2/67	13/ 4/67	24/3/67	13/4/67

Table 4 - Weather during the growing seasons 1965-68.

	Inches Rainfall 1965	Sunshine hours 1965	Average air temperature °F Max. 1965	Average air temperature °F Min. 1965	Inches Rainfall 1966	Sunshine hours 1966	Average air temperature °F Max. 1966	Average air temperature °F Min. 1966
Apr. 30-May 6	0.46	44.1	53.6	39.1	0.25	47.8	58.2	39.9
May 7-May 13	0.31	36.0	60.3	43.3	0.73	44.5	55.3	38.7
14- 20	1.33	38.9	54.9	40.6	0.35	57.1	57.1	41.0
21- 27	0.70	12.6	56.1	44.8	0.55	27.8	57.0	43.6
28-June 3	0.03	35.8	55.0	40.9	0.07	64.4	64.3	42.7
June 4-June 10	0.40	32.6	61.6	45.4	0.65	16.5	57.9	48.7
11- 17	1.13	31.6	61.4	49.3	1.72	11.0	62.9	50.4
18- 24	0.98	37.8	60.0	49.9	1.72	24.0	60.4	47.9
25-July 1	0.36	47.5	61.7	49.4	0.50	46.0	63.7	47.9
July 2-July 8	0.29	27.4	59.0	44.1	0.18	31.1	63.1	50.6
9- 15	1.20	16.9	55.9	46.9	0.81	29.1	60.7	50.1
16- 22	0.55	37.1	61.7	45.4	0	75.5	65.9	43.7
23- 29	3.42	13.2	56.1	48.4	0.71	40.9	61.7	48.0
30-Aug. 5	2.20	48.5	59.0	42.3	3.05	24.2	57.7	44.7
Aug. 6-Aug. 12	0.47	45.6	62.7	44.3	1.39	12.0	62.4	49.4
13- 19	0.13	28.9	64.6	51.1	2.37	25.8	64.1	48.6
20- 26	0.86	36.7	61.2	49.0	1.34	45.7	58.4	43.0
27-Sept. 2	0.52	42.8	58.1	44.9	0.47	7.7	60.0	48.9
Sept. 3-Sept. 9	2.19	4.0	53.3	45.4	0.71	36.3	61.1	51.1
10- 16	0.51	20.5	59.4	47.0	1.07	36.3	60.3	48.4
17- 23	1.25	14.9	57.9	48.0	0	38.8	62.3	48.1
24- 30	1.52	8.2	57.0	45.9	0.23	6.4	55.7	47.4

Table 4 (contd.)

	1967 Inches Rainfall	1967 Sunshine hours	1967 Average air temperature °F Max.	1967 Average air temperature °F Min.	1968 Inches Rainfall	1968 Sunshine hours	1968 Average air temperature °F Max.	1968 Average air temperature °F Min.
Apr. 30-May 6	0.67	34.3	49.7	37.1	3.80	6.4	47.7	38.4
May 7-May 13	1.92	17.3	53.2	42.3	1.13	23.2	47.6	33.4
14- 20	2.16	20.8	47.6	39.0	1.00	37.5	50.7	37.1
21- 27	0.54	40.0	55.1	41.0	0.07	31.5	52.6	39.3
28-June 3	0.71	42.6	59.6	43.4	0.16	22.5	60.0	45.0
June 4-June 10	0.33	48.4	58.3	44.7	0.11	42.0	58.7	43.7
11- 17	0	91.3	65.6	43.1	0	43.0	67.0	46.1
18- 24	0.47	51.9	62.3	47.0	0.61	32.2	60.8	46.1
25-July 1	0.24	32.7	61.3	49.4	0.40	64.2	62.5	46.0
July 2-July 8	0.27	47.5	62.6	47.7	1.50	27.9	59.3	48.1
9- 15	1.02	28.7	60.7	49.6	1.75	6.3	55.3	46.1
16- 22	0.29	37.8	63.8	50.4	2.10	14.9	60.9	48.9
23- 29	0.50	42.8	63.1	49.6	0.17	36.7	63.7	50.1
30-Aug. 5	0.41	42.7	63.6	48.1	0.02	46.2	63.4	48.6
Aug. 6-Aug. 12	1.05	21.8	63.4	50.0	0	49.0	64.1	48.6
13- 19	0.84	22.2	58.4	48.1	1.80	35.0	60.8	45.4
20- 26	0.26	46.9	68.4	51.7	0.34	28.7	63.8	53.7
27-Sept. 2	0.73	43.3	61.7	49.1	0.49	17.0	58.4	47.4
Sept. 3-Sept. 9	0.85	40.9	58.7	45.4	1.13	29.3	61.8	44.6
10- 16	0.19	17.7	59.1	45.1				
17- 23	0.17	15.5	57.1	43.6				
24- 30	1.00	24.8	61.4	46.0				

Table 5 - a) Maximum and minimum temperatures during storage for the duration of planting in Experiment 5.

b) Air temperatures, soil temperature at 9" below the top of the ridge and rainfall over the planting period for Experiment 5 in 1967.

Date	a) Store temperature °F Max.	a) Store temperature °F Min.	b) Air temperature °F Max.	b) Air temperature °F Min.	Soil temperature at 9" below top of the ridge	Rainfall inches
April						
4	42	42	52	43	41.1	0
5	43	43	48	39	41.9	0
6	42	42	43	37	41.0	0.14
7	41	41	44	38	40.3	0.01
8	41	41	45	35	40.5	0.29
9	43	43	42	36	40.8	0
10	44	44	42	39	41.0	0.01
11	48	48	44	37	40.8	0
12	42	42	47	36	40.1	0
13	42	42	48	35	40.2	0
14	43	43	61	34	42.5	0.05
15	45	45	57	41	43.8	0
16	46	46	58	40	44.3	0
17	43	43	57	47	45.9	0
18	46	46	48	33	44.9	0
19	43	43	50	38	45.0	0.02
20	40	40	50	41	44.3	0.09
21	38	38	49	31	43.0	0
22	38	38	57	27	42.0	0
23	42	42	50	29	42.9	0.04
24	44	44	49	28	43.2	0.04
25	46	46	55	41	43.3	0
26	44	44	50	41	45.2	0.01
27	44	44	60	44	45.0	0
28	44	44	65	46	47.0	0
29	46	46	66	45	48.7	0
30	48	48	54	46	49.3	0

<u>Table 6</u> - Potential transpiration and rainfall for 1967 (Loanhead 480').

	Potential transpiration	Rainfall	Deficit
	inches of water		
April	2.04	0.46	-1.58
May	2.86	5.00	+2.14
June	4.16	0.76	-3.40
July	3.27	2.00	-1.27
August	2.58	2.05	0.53
September	1.61	2.34	+0.73

Growth Analysis Data (1964-65) - Values for I, A, M, O averaged over the current season's treatments (N^1, M^1, O^1), seed size and replicate.

Table 7 - Effect of the previous season's treatments on total dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
1	28.0	162.0	382.2	604.1	809.4
A	21.8	150.7	408.0	603.8	802.2
M	28.2	151.3	351.3	591.8	772.5
O	29.9	138.0	375.3	560.3	778.5
MAJESTIC					
I	25.5	154.3	385.2	688.0	875.2
A	25.3	170.3	403.2	556.3	840.5
M	25.5	170.2	385.1	644.8	886.2
O	21.7	142.3	422.6	659.2	807.4
S.E.	±3.24	± 13.85	± 24.46	± 32.65	± 33.92

Table 8 - Effect of the previous season's treatments on tuber number per 3 plants with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
I	-	18.3	57.8	63.8	67.6
A	-	24.6	53.4	61.5	53.4
M	-	22.1	50.3	53.3	50.5
O	-	18.3	48.2	50.3	54.4
MAJESTIC					
I	-	34.9	46.4	49.4	46.5
A	-	29.7	49.0	44.4	42.6
M	-	33.3	48.3	50.4	46.0
O	-	29.3	46.7	44.6	42.2
S.E.		± 3.10	± 3.42	± 3.72	± 2.66

Table 9 - Effect of the previous season's treatments on tuber fresh weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
I	-	117.8	1040.1	2376.3	3599.4
A	-	150.0	1243.8	2482.1	3631.6
M	-	121.4	947.9	2165.9	3390.7
O	-	101.0	1069.2	2188.7	3417.9
MAJESTIC					
I	-	133.0	1010.4	2214.1	3487.7
A	-	124.3	1064.2	2047.3	3390.0
M	-	174.3	1009.6	2262.8	3459.0
O	-	97.3	1137.6	2232.7	3181.0
S.E.		± 32.26	± 80.69	± 164.85	± 145.24

Table 10 - Effect of the previous season's treatments on tuber dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
I	-	19.5	150.7	382.3	637.2
A	-	23.2	185.7	392.9	645.0
M	-	18.9	134.3	382.6	609.4
O	-	9.4	158.2	345.0	619.1
MAJESTIC					
I	-	19.6	152.7	363.5	616.1
A	-	26.4	165.3	328.8	606.4
M	-	26.8	152.8	361.2	628.9
O	-	18.1	173.2	385.9	571.9
S.E.		± 4.07	± 12.74	± 21.27	± 27.73

Table 11 - Effect of the previous season's treatments on foliage dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
I	28.0	142.5	231.5	221.8	172.2
A	21.8	127.5	222.3	210.9	157.2
M	28.2	132.3	217.1	209.2	163.1
O	29.9	128.6	217.2	215.3	159.4
MAJESTIC					
I	25.5	134.7	232.6	324.5	259.1
A	25.3	143.8	237.9	227.4	234.1
M	25.5	143.4	232.3	283.7	257.3
O	21.7	124.2	249.4	273.3	235.5
S.E.	± 3.24	± 12.29	± 14.79	± 20.52	± 12.73

Growth Analysis Data (1965-66) - Values for N, M, O averaged over B.O., MAT., the current season's treatments (A, B, C) and replicate; values for B.O., MAT., averaged over N, M, O, the current season's treatments and replicate.

Table 12 - Effect of the previous season's treatments on total dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
N	15.0	141.2	361.6	758.2	559.1
M	13.6	134.8	371.1	681.2	667.9
O	17.4	158.6	402.9	694.2	643.7
S.E.	± 1.02	± 14.37	± 22.82	± 32.84	± 47.61
burned off	14.8	139.0	358.4	710.2	590.7
mature	15.8	150.7	398.7	712.2	656.4
S.E.	± 0.83	± 11.73	± 18.3	± 26.81	± 38.87
MAJESTIC					
N	18.7	226.3	440.4	768.7	984.1
M	18.1	197.8	470.3	846.1	916.1
O	20.1	196.1	470.5	841.4	884.6
S.E.	± 1.02	± 14.37	± 22.82	± 32.84	± 47.61
burned off	19.3	220.8	465.9	827.8	937.0
mature	18.6	192.6	455.0	809.7	919.5
S.E.	± 0.83	± 11.73	± 18.3	± 26.81	± 38.87

Table 13 - Effect of the previous season's treatments on tuber number per 3 plants with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
N	-	61.1	67.7	69.3	43.4
M	-	64.6	76.4	66.5	45.1
O	-	64.7	63.2	69.7	44.5
S.E.	-	± 3.88	± 4.82	± 3.39	± 2.75
burned off	-	63.4	68.7	69.8	43.2
mature	-	63.6	69.5	67.2	45.5
S.E.	-	± 3.17	± 3.94	± 2.76	± 2.24
MAJESTIC					
N	-	79.3	79.2	68.4	57.2
M	-	77.3	76.6	70.8	52.2
O	-	68.4	76.8	67.6	51.8
S.E.	-	± 3.88	± 4.82	± 3.39	± 2.75
burned off	-	77.1	79.7	71.7	55.4
mature	-	72.9	75.4	66.1	52.1
S.E.	-	± 3.17	± 3.94	± 2.76	± 2.24

Table 14 - Effect of the previous season's treatments on tuber fresh weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
N	-	234.8	1239.1	3153.0	2442.2
M	-	218.4	1293.5	2794.8	2712.4
O	-	260.9	1330.6	2793.4	2763.8
S.E.	-	± 25.53	± 93.21	± 143.83	± 203.42
burned off	-	242.2	1200.7	2898.7	2474.0
mature	-	233.9	1374.7	2928.8	2804.9
S.E.	-	± 20.85	± 76.11	± 117.44	± 166.09
MAJESTIC					
N	-	381.8	1367.1	2923.7	3823.7
M	-	348.9	1425.7	3111.9	3436.4
O	-	311.9	1474.8	3264.9	3667.7
S.E.	-	± 25.53	± 93.21	± 143.83	± 203.42
burned off	-	384.5	1449.9	3180.6	3628.6
mature	-	310.6	1395.2	3019.7	3656.7
S.E.	-	± 20.85	± 76.11	± 117.44	± 166.09

Table 15 - Effect of the previous season's treatments on tuber dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
N	-	34.1	201.3	574.4	465.2
M	-	31.2	207.9	524.0	523.7
O	-	36.0	217.3	523.2	522.3
S.E.	-	± 3.61	± 16.11	± 25.97	± 43.29
burned off	-	34.4	193.2	535.1	467.1
mature	-	33.1	224.5	545.9	540.4
S.E.	-	± 2.95	± 13.15	± 21.21	± 35.35
MAJESTIC					
N	-	54.1	227.1	557.7	751.0
M	-	49.4	232.4	596.2	672.1
O	-	43.8	239.7	601.2	657.9
S.E.	-	± 3.61	± 16.11	± 25.97	± 43.29
burned off	-	54.3	238.6	602.0	705.7
mature	-	43.8	227.5	568.0	681.6
S.E.	-	± 2.95	± 13.15	± 21.21	± 35.35

Table 16 - Effect of the previous season's treatments on foliage dry weight (g/3 plants) with time.

ARRAN PILOT	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5
N	15.0	107.1	160.2	183.8	93.9
M	13.6	103.6	163.2	157.2	144.3
O	17.4	122.6	185.6	171.1	119.9
S.E.	± 1.02	± 12.59	± 9.92	± 11.45	± 20.49
burned off	14.8	104.6	165.2	175.1	122.7
mature	15.8	117.6	174.2	166.3	116.1
S.E.	± 0.83	± 10.28	± 8.10	± 9.35	± 15.90
MAJESTIC					
N	18.7	172.2	213.3	211.0	233.1
M	18.1	148.4	237.9	249.9	244.0
O	20.1	152.3	230.8	240.2	226.7
S.E.	± 1.02	± 12.59	± 9.92	± 11.45	± 19.47
burned off	19.3	166.5	227.3	225.8	231.4
mature	18.6	148.8	227.5	241.6	237.9
S.E.	± 0.83	± 10.28	± 8.10	± 9.35	± 15.90

Table 17 - Effect of sprouting, planting date and sampling occasion on tuber number in grades (per 18 plants totalled over seed sizes and replicates).

	SPROUTED													
	Lift 2							Lift 3						
Planting date	0-25	25-50	50-100	100-150	150-200	200-300	>300g	0-25	25-50	50-100	100-150	150-200	200-300	>300g
1	283							260	65	15				
2	241							249	60	14	1			
3	198							300	59	4				
4	282							245	57	14	1			
5	263							244	36	8				
6	203							283	55	3				
7	171							257	54	11				
8	319							208	72	36	3			
9	328	6						223	58	30				
10	320	6						235	59	21				
11	319	17	4					208	72	48	5			
12	313	8						212	49	31	7			
13	280							214	57	35	1			
14	342	2						249	64	12				

Table 17 (contd.)

Planting date	SPROUTED													
	Lift 4							Lift 5						
	0-25	25-50	50-100	100-150	150-200	200-300	300g	0-25	25-50	50-100	100-150	150-200	200-300	300g
1	131	43	66	30	8	1		158	21	41	35	36	28	12
2	165	48	72	26	4			126	25	44	41	28	32	7
3	166	44	63	22	2			148	22	57	29	25	27	13
4	224	63	74	26	1			157	31	41	41	29	23	14
5	182	45	62	33	2			132	26	42	35	32	29	3
6	148	48	74	20	2	1		117	27	44	32	17	24	10
7	199	47	50	18	6			124	14	35	47	36	22	6
8	143	39	57	43	9			111	23	32	31	28	28	13
9	164	30	61	34	11	1	1	125	29	37	35	25	27	12
10	146	38	64	22	5	2		123	30	38	29	27	34	10
11	190	19	57	48	28			148	26	43	35	35	27	12
12	144	19	56	43	25	4	1	123	24	42	35	39	30	8
13	176	36	70	39	11	2		148	26	51	39	36	27	9
14	203	33	58	31	4	4		147	30	52	26	25	25	10

<u>Table 17</u> (contd.)

Planting date	Lift 2							Lift 3						
	UNSPROUTED													
	0-25	25-50	50-100	100-150	150-200	200-300	300g	0-25	25-50	50-100	100-150	150-200	200-300	300g
1	192							267	58	12				
2	249							215	49	7				
3	198							283	40	6				
4	211							315	30	12				
5	221	4						205	55	34	2			
6	289							237	54	29				
7	248	2						198	59	19				
8	323	8						185	62	40	8	1		
9	332	2						183	58	56	3			
10	350							194	75	47	5			
11	352	2						168	81	48	3			
12	324	3						193	71	43	5	1		
13	263	4						261	85	19	2			
14	326							239	80	29				

Table 17 (contd.)

UNSPROUTED

Planting date	Lift 4							Lift 5						
	0-25	25-50	50-100	100-150	150-200	200-300	300g	0-25	25-50	50-100	100-150	150-200	200-300	300g
1	137	50	58	18	0	1		86	23	31	34	22	23	16
2	151	40	58	27	2	1		141	29	38	41	28	22	10
3	162	44	62	19	3	2		107	19	52	30	25	27	7
4	152	50	52	20	0	0		98	17	32	30	23	24	5
5	96	25	44	39	13	8	2	112	17	43	37	31	25	11
6	131	29	44	36	18	2		135	14	28	34	29	28	10
7	138	36	55	44	22	2		93	22	26	25	19	30	11
8	151	26	56	42	15	8		97	21	40	40	28	42	26
9	162	55	69	41	10	7		116	21	40	32	33	39	21
10	160	39	82	36	6	4	1	131	27	45	33	29	26	12
11	140	38	48	48	17	9	1	102	28	38	39	29	34	10
12	131	25	63	38	16	9		129	28	51	38	33	38	8
13	152	42	66	41	16	1		132	23	43	45	29	43	11
14	183	64	84	26	4	0		119	23	60	42	24	32	8

Table 18 - Effect of planting date, and sampling date on total tuber number per plant in both sprouted and unsprouted seed tubers.

SPROUTED

Planting occasion	Sample Lifts 1	2	3	4	5
1	4.2	15.7	18.9	15.5	18.4
2	1.4	13.4	18.0	18.3	16.8
3	0.7	11.1	20.2	17.5	18.1
4	3.2	15.7	17.6	21.6	19.7
5	1.4	14.6	16.9	19.0	16.8
6	1.6	11.3	18.9	16.3	15.0
7	1.5	9.5	17.9	19.0	15.8
8	2.8	17.8	16.9	17.2	14.7
9	0.8	18.6	17.3	16.8	16.1
10	1.4	18.2	18.6	16.1	16.2
11	4.1	18.9	18.5	19.2	18.1
12	4.6	17.8	16.6	16.1	16.7
13	3.0	15.6	17.1	18.0	19.1
14	0.6	19.1	18.1	19.4	17.5

UNSPROUTED

Planting occasion	1	2	3	4	5
1	0.2	10.7	18.7	16.1	12.7
2	0	11.7	15.0	16.4	17.2
3	0.4	11.0	19.6	16.2	14.8
4	0.1	11.7	19.8	16.1	12.8
5	1.0	12.5	16.4	13.6	15.9
6	1.3	16.1	17.8	15.2	15.4
7	0.4	13.9	15.3	16.7	15.6
8	0.6	18.4	17.3	18.2	16.2
9	0.4	18.6	18.1	19.1	16.8
10	0.3	19.4	17.8	18.3	18.5
11	0.2	19.7	17.7	16.7	15.6
12	0.2	18.2	17.9	15.7	18.0
13	0	17.7	20.4	17.7	18.1
14	0	18.1	19.4	20.2	18.2

Table 19 - Effect of planting date and sampling date on total tuber fresh weight per plant in both sprouted and unsprouted seed tubers.

Planting occasion	1	2	3	4	5
			SPROUTED Sample lifts		
1	3.6	69.8	295.9	693.0	1457.6
2	1.6	33.3	283.2	690.0	1368.3
3	0.2	41.5	240.5	593.8	1407.8
4	3.0	35.9	283.9	640.8	1566.4
5	1.1	43.7	210.1	662.7	1273.9
6	1.8	30.8	238.2	571.4	1194.6
7	0.8	26.7	243.9	555.4	1317.9
8	5.7	71.3	350.2	770.9	1298.2
9	0.8	99.2	320.6	700.9	1249.0
10	0.8	75.7	367.7	615.9	1338.8
11	9.3	137.9	425.6	979.4	1420.9
12	6.9	74.3	332.9	897.5	1396.3
13	4.2	47.1	301.6	787.7	1443.9
14	0.4	41.8	242.9	715.7	1275.3
			UNSPROUTED		
1	0.1	29.1	248.8	567.7	1284.1
2	0	21.0	210.8	609.3	1315.5
3	0.2	26.0	207.4	564.4	1246.8
4	0	33.1	201.6	510.6	1047.9
5	0.6	77.2	313.2	835.5	1390.6
6	1.4	58.8	307.8	675.8	1272.6
7	0.3	48.9	272.8	962.2	1444.7
8	0	84.4	434.6	908.9	1834.7
9	0.3	82.7	425.9	903.7	1679.9
10	0	65.3	405.3	839.8	1347.6
11	0	68.1	444.9	939.4	1473.5
12	0	68.2	426.3	799.6	1555.8
13	0	44.2	341.3	823.8	1615.4
14	0	34.6	352.4	769.1	1500.8

Table 20 - Effect of planting date and sampling date on tuber dry weight (g/plant) in both sprouted and unsprouted seed tubers.

SPROUTED

Planting occasion	Sample lifts 1	2	3	4	5
1	0	9.7	49.0	123.5	286.8
2	0	5.1	46.4	121.8	280.7
3	0	5.8	38.5	103.9	272.6
4	0	4.9	44.1	110.8	306.8
5	0	5.9	34.6	123.8	256.2
6	0	4.1	38.0	96.8	226.0
7	0	3.6	39.1	94.5	250.0
8	0	10.5	59.4	134.6	247.2
9	0	9.0	55.6	127.4	235.7
10	0	11.4	45.7	108.2	258.3
11	7.7	21.9	70.2	186.3	281.4
12	6.0	11.4	55.9	165.5	278.6
13	1.3	7.1	47.8	137.8	280.6
14	0	6.2	37.6	124.4	238.6

UNSPROUTED

Planting occasion	1	2	3	4	5
1	0	4.6	40.9	96.0	249.1
2	0	4.9	33.7	103.1	239.9
3	0	4.4	34.1	96.4	231.6
4	0	5.1	32.2	86.4	194.9
5	0	12.1	50.1	149.0	262.4
6	0	9.0	47.9	137.2	237.3
7	1.0	7.7	43.2	171.3	274.1
8	0	12.7	69.8	162.4	351.3
9	0	12.9	68.6	162.7	327.1
10	0	9.9	61.2	154.0	266.0
11	0	13.2	74.5	170.0	284.8
12	0	10.3	67.3	140.9	300.9
13	0	6.6	51.0	148.7	307.7
14	0	5.1	54.3	136.0	292.7

Table 21 - Effect of planting date and sampling date on $\log_e$ total dry weight (g/plant) in both sprouted and unsprouted seed tubers.

Planting occasion	Sample lifts 1	2	3	4	5
			SPROUTED		
1	2.33	3.56	4.77	5.27	5.93
2	2.16	3.31	4.72	5.30	5.89
3	1.97	3.27	4.62	5.20	5.92
4	2.18	3.38	4.72	5.26	6.01
5	1.99	3.40	4.54	5.35	5.80
6	1.92	3.28	4.66	5.18	5.82
7	1.79	3.20	4.59	5.14	5.83
8	2.31	3.88	4.91	5.45	5.83
9	2.16	3.88	4.84	5.37	5.79
10	2.13	3.90	4.69	5.30	5.87
11	3.08	4.23	4.95	5.71	5.90
12	2.93	3.88	4.78	5.55	5.91
13	2.41	3.75	4.74	5.47	5.97
14	1.91	3.73	4.65	5.38	5.83
			UNSPROUTED		
1	1.72	3.46	4.70	5.24	5.81
2	1.65	3.52	4.68	5.30	5.86
3	1.72	3.46	4.61	5.27	5.85
4	1.70	3.55	4.62	5.18	5.70
5	2.32	3.90	4.81	5.52	5.89
6	2.28	3.77	4.80	5.44	5.84
7	2.23	3.81	4.78	5.67	5.95
8	2.49	4.16	5.07	5.61	6.17
9	2.29	4.12	5.05	5.54	6.08
10	2.30	4.01	4.94	5.54	5.89
11	2.18	4.04	5.09	5.62	5.94
12	2.13	3.89	5.08	5.49	6.00
13	2.04	3.76	4.91	5.57	6.06
14	2.06	3.68	4.90	5.47	5.99

<u>Table 22</u> - Effect of planting date and sampling date on foliage dry weight (g/plant) in both sprouted and unsprouted seed tubers.

Planting occasion	Sample lifts 1	2	3	4	5
			SPROUTED		
1	10.3	25.6	69.0	72.4	89.6
2	8.7	22.3	65.7	77.9	79.8
3	7.2	20.4	63.3	76.8	99.5
4	8.8	24.5	68.7	82.4	100.6
5	7.3	24.1	59.1	87.3	75.1
6	6.8	22.6	68.2	81.6	110.0
7	6.0	20.9	59.6	76.3	89.0
8	10.2	37.8	76.1	99.4	93.4
9	8.7	39.4	70.8	86.7	92.5
10	8.4	38.1	62.9	92.7	97.6
11	14.0	47.0	70.8	88.4	84.3
12	12.7	37.0	63.5	91.7	91.6
13	9.8	35.4	67.3	99.7	112.8
14	6.8	35.5	66.7	92.7	101.9
			UNSPROUTED		
1	5.6	27.3	68.7	93.0	86.2
2	5.2	28.9	74.4	97.7	111.6
3	5.6	27.4	66.7	97.4	117.0
4	5.5	29.9	69.2	90.5	76.8
5	10.2	37.1	72.6	100.0	100.7
6	9.8	34.4	74.1	92.8	106.7
7	9.3	37.6	76.3	119.6	109.9
8	12.1	51.2	90.0	112.1	127.3
9	9.9	48.5	86.0	93.2	109.4
10	9.9	45.3	78.3	99.0	95.3
11	8.8	43.9	88.7	107.0	95.4
12	8.4	38.6	93.2	100.8	100.9
13	7.7	36.4	84.8	115.0	119.4
14	7.8	34.5	80.6	101.0	107.2

Table 23 - Days from emergence to sampling (E) in experiment 5, 1967.

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
			SPROUTED		
1	24	32	47	62	87
2	21	29	44	59	84
3	22	30	45	60	85
4	21	29	44	59	84
5	19	27	42	57	82
6	17	25	40	55	80
7	16	24	39	54	79
8	18	31	54	59	80
9	17	30	53	58	79
10	15	28	51	56	77
11	18	32	46	63	81
12	16	30	44	61	79
13	13	27	41	58	76
14	14	28	40	59	77
			UNSPROUTED		
1	16	29	42	57	78
2	16	29	42	57	78
3	16	29	42	57	78
4	16	29	42	57	78
5	19	33	47	64	82
6	19	32	47	64	82
7	17	31	45	62	80
8	20	35	52	67	87
9	17	32	49	64	84
10	16	31	48	63	83
11	17	32	49	64	84
12	12	29	46	61	81
13	13	28	45	60	80
14	14	29	46	61	81